ARCHIVES

OF

OPHTHALMOLOGY

AND

OTOLOGY.

EDITED AND PUBLISHED SIMULTANEOUSLY IN ENGLISH AND GERMAN

BY

PROF. H. KNAPP, M.D., IN NEW YORK, AND PROF. S. MOOS, M.D., IN HEIDELBERG.

VOLUME I., NO. 2.

NEW YORK:
WILLIAM WOOD & CO.

CARLSRUHE: CHR. FR. MULLER'SCHE HOFBUCHHANDLUNG,
MDCCCLXIX.

The New York Printing Company,
81, 83, *and* 85 *Centre St.*,
New York.

CONTENTS OF NUMBER II.*

* In the table of contents for the first number, the title of a paper has been omitted, viz.:—

PURULENT OTITIS MEDIA, CAUSED BY THE NASAL DOUCHE, AND ACCOMPANIED BY DOUBLE HEARING.

By H. KNAPP.

THE use of *Weber's* nasal douche for diseases of the naso-pharyngeal region has of late become very extensive. Some recent publications, however, show that it is not without serious danger. Dr. *D. B. St. John Roosa* describes in the first number of these Archives (p. 259, etc.) a case in which the origin of a purulent inflammation of the middle ear, of the very severest kind, could be traced to the use of the nasal douche. He adds that he had observed other cases in which the nasal douche was followed by bad symptoms, and that it hardly ever could be tolerated for any length of time. *S. Moos*, in a note to the German translation of Roosa's communication, confirms these views by stating that he saw the fluid which had been injected into the nostril by Weber's douche, flow out of the ears in two cases of perforation of the drum-head. Although the application of the douche is not hurtful in such cases, they prove that

water thus introduced into the posterior nasal space may penetrate through the Eustachian tubes into the tympanic cavity. Moos, too, saw a case in which an acute aural catarrh was brought about by the nasal douche. The practical importance of these observations induces me to communicate a case of a similar kind :—

A merchant of New York, 32 years of age, was in the habit of injecting, by Weber's douche, warm water into his nose for chronic catarrh. He once took *cold water*, and felt, immediately after the injection, considerable pain in both ears, disappearing, however, very soon. Since that time he used warm water for six months without any unpleasant symptoms. Then he employed cold water once again, and experienced instantly in his left ear a severe pain, which soon abated, but nevertheless continued dull and annoying for a fortnight. Then suddenly it increased very much, was combined with headache, throbbing in the ear, loss of appetite, and deafness. Three days later an abundant purulent discharge from the left ear set in. He came to my office presenting all the symptoms of a very severe otitis media, with perforation of the membrana tympani. He remained under my treatment from March 6th to April 11th. Three weeks after his first call a great improvement had been obtained, the discharge was stopped, and the perforation in the drum-head closed for four days. Then an exacerbation and a new perforation occurred. The discharge kept flowing for a fortnight, when again an improvement was obtained, and the patient left New York to complete his recovery under the care of his father, a physician in the neighborhood of Philadelphia.

There is no doubt that the purulent inflammation of the middle ear was caused by the flowing of *cold* water into the tympanic cavity. Whether warm water sometimes or usually passed into the drum during the use of Weber's douche cannot be ascertained, since the patient

never felt it. I am satisfied that water can penetrate into the drum only when the patient accidentally swallows during the time the current is running over the orifices of the Eustachian tubes. It is easily explainable that cold water is more apt to provoke involuntary swallowing than warm. Moreover, the latter, when passing into the tympanum, would probably not cause much reaction or bad consequences. It therefore is certainly less objectionable than the use of cold water in cleansing the nasal and upper pharyngeal region. Since the observation above related, and the communications of *Roosa* and *Moos*, I have not recommended any more the use of the nasal douche, but applied injections of astringent remedies by the posterior nares syringe. They are disagreeable for a great many patients, producing very unpleasant fits of sneezing and coughing, but their action is efficient, and, as it seems, devoid of danger. If we inject only small quantities of fluid, which is mostly sufficient, there is commonly no unpleasant reaction.

Besides its origin, the above case was very remarkable for a symptom not much noticed yet, viz., *double hearing with both ears. Tröltsch* and *Politzer* mention its occurrence only with two lines; *Moos* records in his "Klinik der Ohrenkrankheiten," p. 319, etc., what is known on it. There are three incomplete observations in older literature, to which are added two of *Moos* himself, and one of *Von Wittich.* . The first of Moos' patients, suffering from acute aural catarrh, heard simultaneously the third of each tone he was singing. The catarrh and double

hearing disappeared both together very soon. The second patient had impairment of hearing from chronic aural catarrh for ten years. One evening, to shorten a fit of his habitual asthma, he anæsthetized himself by chloroform. On awaking his deafness was very much worse, and he heard all the sounds of the upper three octaves of a piano double. During the course of some months his hearing power diminished still further, the double hearing continued for some time, and ultimately all musical sounds appeared to him so perverse that music in general, which he had been very fond of before, became a perfect horror to him. In none of these two cases mention is made which ear perceived rightly the natural tone, nor whether the pseudo-tone was higher or lower in pitch. The only well-analyzed case of the few cases of double hearing which are on record up to this day, is the observation made by Prof. *Von Wittich* on himself. The excellent physiologist of Koenigsberg noticed, four weeks after an acute purulent otitis media, that he heard *all the tones of the middle octave of a piano half a note higher* with the diseased ear than with the healthy one. His explanation is, that an exudation into the tympanic cavity, by altering the pressure of the fluid in the labyrinth, had changed the tuning of the terminal fibres of the auditory nerve.

When I examined the patient whose history I have sketched above, three days after the discharge had set in, I found in the diseased ear the hearing power for noises very much diminished (a watch of 6′ hearing

distance was heard from $\frac{1}{2}''$), whilst musical sounds were nearly as sharply perceived as in the normal state. A large tuning-fork, placed on the glabella, was *heard double, and in the affected ear more strongly and about two tones higher than in the sound ear.* On trial with a piano I found out that the same anomaly existed for the tones of the middle and next higher octaves, but not for the deeper ones. It was not distinctly marked at which note of the musical scale the double hearing began, nor where it terminated. This anomaly existed unchanged during the first week, as long as the perforation of the membrana tympani was large and the discharge abundant. Then the double sounds gradually came nearer to each other in pitch, until, at the end of three weeks, they hardly differed by half a tone, and sometimes were heard separately only by strained attention. After the relapse the double hearing was again a little better perceived, but the two tones never differed so much as in the beginning; moreover, their difference in pitch was changing from day to day. I have not heard of the patient since he left New York.

This observation has many features in common with that of *Von Wittich*, above all, the origin of the anomaly in an acute purulent otitis media. The principal differences of both cases are the following: 1st. The pseudo-tone (that of the diseased ear) was higher in Wittich's, lower in mine, than the right tone. 2d. The difference of pitch between real and pseudo-tone was greater in my case than in Wittich's. 3d. The differ-

ence of pitch between both tones was changing in my case, but constant in that of *Von Wittich.*

I shall try to account for these differences, together with giving an explanation of the whole anomaly. The latter is most appropriately termed *diplacusis binauricularis,* in analogy with a similar anomaly of the organ of sight, viz., diplopia binocularis. *Helmholtz's* theory is perfectly adapted to explain binauricular diplacusis. In conformity with this theory we may compare the cochlear portion of the inner ear with a stringed instrument. Corti's arcs or fibres—the strings—are so tuned as to yield all the sounds of the musical scale. Both cochleæ represent two instruments in perfect accord. If a sound is produced in the air, the vibrations of the latter will be transmitted through both membranæ tympani and the chain of the ossicles to those strings of Corti's organ which are tuned for this sound, and thus sympathetic vibrations are occasioned in Corti's fibres, and conveyed to the brain by the filaments of the auditory nerve connected with the vibrating fibres of Corti's organ. The same external sound will excite in either cochlea corresponding (identical) acoustic nerve fibres by producing sympathetic vibrations in corresponding (identical) arcs of Corti's organ. In analogy with similar conditions of both retinæ, *those fibres of both cochleæ may be called corresponding or identical, the simultaneous and equivalent excitement of which generates but* ONE *sensation of sound.* This constitutes the anatomical and physiological foundation of single hearing with both

ears, in a similar manner as we see single with both eyes.

Now, suppose the strings of one instrument (Corti's organ) are tighter drawn, then this instrument will be differently, that is, higher tuned, so that a string which formerly made f. i. 300 vibrations per second now makes 350 per second. Say 300 vibrations per second correspond to the tone *c*, 350 to the tone *e*. If, now, the latter tone, *e*, is sounded at any musical instrument, it will excite sympathetic movements in all strings so tuned as to perform 350 vibrations per second. (I may disregard entirely the harmonics.) In the healthy ear this will be Corti's fibre corresponding to the sound *e*, but in the diseased ear 350 vibrations are now performed by a fibre which formerly performed only 300 per second, and which, of course, is still connected with that auditory nerve-fibre which always committed the impression of 300 vibrations, that is, the tone *c*, to the brain. Therefore this ear will engender the perception of the lower sound *c*, whilst at the same time the other one will engender the perception of the higher sound *e*. Such were about the conditions in the case of double hearing observed by me.

The opposite state must have been present in *Von Wittich's* case. He heard with the diseased ear the tone higher than with the healthy one. Suppose he heard with the latter the sound *c* (300 vibrations per second), and with the diseased the sound *d* (say 325 vibrations per second), then Corti's fibre, tuned in the healthy state

to 325 vibrations, must have been so much relaxed that it now made only 300 per second. An external sound, *c*, of 300 vibrations per second, will induce sympathetic vibrations in that of Corti's arc of either ear which is tuned to 300 vibrations. In the healthy ear the right sound *c* is perceived, but in the diseased ear the relaxed arc will continue to excite the auditory fibre which always conducted the impression of 325 vibrations per second, that is, of the sound *d*, to the brain. *Von Wittich* made a very ingenious experiment to confirm this theory. If two tuning-forks, differing in pitch by half a tone, were so put before the ears that the lower one was before the diseased, the higher before the healthy ear, only one sound was perceived. The tuning-fork which yielded a lower sound produced sympathetic undulations in the relaxed Corti's arc which formerly was tuned half a tone higher, and now the nerve connected with it is excited with its corresponding nerve in the other cochlea.

Thus it is evident that diplacusis binauricularis may be of two kinds, by *false higher tuning*, *tightening*, and by *false lower tuning*, *relaxing*, *of Corti's organ. In the latter the pseudo-tone will be higher*, *in the former it will be lower*, *than the right tone.*

The greater the difference in pitch, *the greater will be the degree of false tuning*, *either by increased tension or by relaxation of Corti's organ.* This principle explains the second and third points of difference between my case and that of *Von Wittich*. There was, at the beginning of my observation, a morbid action on the cochlea

about four times as intense as in Von Wittich's case. This morbid action, however, was not constant during the course of my observation, but decreased in proportion with the decreasing intensity of the inflammation. It was scarcely yet perceptible when the discharge had stopped and the perforation of the drum-head was closed. In a case of Dr. *Gumpert* (see *Moos*, l. c., p. 319) the difference of pitch of both sounds varied between a third, fourth, and octave during one week, and then disappeared entirely.

Of what nature the changes are which produce false tuning of Corti's organ, I am not at all prepared to answer. *Von Wittich* assumes that exudation into the tympanic cavity changes the pressure of the fluid in the labyrinth. In his case the membrana tympani seems to have been entire at the time when diplacusis was noticed, for he adds that neither filling of the auditory canal with water, nor inflation of the tympanum with air, produced any alteration in the double hearing. In my case diplacusis of opposite kind existed, with perforation of the membrana tympani. Is the integrity of the membrana tympani essential in relaxing Corti's organ? Does its perforation produce tightening of it? I am unable to answer these questions. The first of *Moos*' cases, acute aural catarrh, seems to be analogous with Wittich's observation. "The patient heard simultaneously the third of every tone." If here, what is not stated, but seems to be understood, the third was the pseudo-tone, then there existed, like in Wittich's observation, dipla-

cusis by relaxation of Corti's organ. The drum-head was not ruptured.

The other observation of *Moos*, where diplacusis was occasioned by anæsthetizing with chloroform in a case of chronic aural catarrh, seems to be an example of idiopathic false tuning of Corti's organ, that is, not dependent on inflammatory changes in the middle ear. I think that, for the present, it is of greater importance to collect more facts relative to this anomaly than to seek for a theory.

The symptom of double hearing, when further studied, may be not only of physiological significance, but assume practical importance. It may guide our prognosis and treatment, by demonstrating that in the respective cases the labyrinth is either primarily affected or participates in some other disease. I suppose also that diplacusis binauricularis will be more frequently noticed than has been the case hitherto, if our attention be directed to it. With regard to future investigations, I propose that our inquiries should try to solve the following questions:—

1. How great is the *difference of pitch* between the two sounds?

2. Has the *pseudo-tone the same intensity and clang-tint* (timbre) as the right tone (that of the healthy ear)?

3. Are these *differences constant or varying* during the duration of the anomaly?

4. Is the *pseudo-tone higher or lower than the right tone* (diplacusis by relaxation or tension of Corti's fibres)?

5. Is it possible to *obtain single hearing* by producing tones of different pitch before either ear? The tuning-fork placed before the diseased ear ought to differ so much in pitch from the tuning-fork placed before the healthy ear as the pseudo-tone differs from the right tone, but the difference in pitch must be of opposite direction, f. i., if the pseudo-tone is half a tone higher than the right tone, then the tuning-fork placed before the diseased ear must be half a tone lower than that before the healthy ear. If the pseudo-tone is lower than the right tone, then the tuning-fork before the diseased ear must be so much lower.

6. At which heights of the musical scale does double hearing begin and terminate, that is, *how great is the range of double hearing?*

7. Are the *limits*, on the musical scale, *between single and double hearing distinct or fading away gradually?*

8. If the entire Corti's organ of one ear be differently tuned from that of the other ear, compound tones and pure chords must appear dissonant in binauricular, but consonant in monauricular hearing, also when in the latter case the healthy ear is excluded from the act of hearing. But if only a part of Corti's organ of one ear be differently tuned from the corresponding part of the other ear, all compound tones and the purest chords must appear dissonant in monauricular as well as in binauricular audition. All music must be a horrible dissonance, as in the one of *Moos'* cases. The examination has to determine of *what kind these dissonances in monauricular*

and binauricular audition are, which will be possible by analyzing the anomaly according to Helmholtz's theory.

9. What is the *cause of diplacusis?* Is the latter dependent on a primary lesion of the labyrinth, or consequent to morbid processes in the middle ear? In what state is the membrana tympani? Is there any change in intra-auricular pressure?

A complete investigation of this kind may, at first, be fraught with difficulties, and perhaps deemed resultless; but let me remind the reader that diplopia, not long ago, was an abstruse subject too, which has now become most valuable with regard to diagnosis, prognosis, and treatment of a large group of eye-diseases.

THE INFLUENCE OF SPECTACLES ON THE OPTICAL CONSTANTS AND VISUAL ACUTENESS OF THE EYF.

—

BY H. KNAPP.

(A.) INFLUENCE OF SPECTACLES ON THE ORDINARY EYE.

EVERY oculist at the present day is fully convinced that an accurate determination of the acuteness of vision (S) is of the greatest importance in the practice of ophthalmology. The older methods are now all given up in favor of ascertaining S by a rational system of test-types. In cases of anomalous refraction, S is found out by means of convex or concave glasses neutralizing the anomaly of refraction. That, in doing so, a certain degree of inaccuracy is introduced by disregarding the magnifying and diminishing influence of these glasses is evident, but the amount of this inaccuracy has not yet been calculated. Even *Donders*, in his very exhaustive treatise on the Anomalies of Accommodation and Refraction, does not touch this question. He says (p. 152) that, without further determination, a comparison of THE VISUAL ANGLES can only be made if the

visual object can be accurately seen *with or without auxiliary glasses.*

I purpose now to examine what influence on the visual acuteness these auxiliary glasses exert in ametropic eyes.

It is known that ametropia is caused not by any notable changes in the refracting media and their surfaces of separation, but by changes of position of the retina. Therefore we may assume that the optical constants of ametropic eyes are equal to those of emmetropic ones. I shall take as a basis for the calculation the values of *Listing's diagrammatic eye* given in most text-books, for instance, *Helmholtz's* Physiological Optics, p. 111, and *Donders'* Accom. and Refraction, p. 67. (In the latter there is a misprint: line 7 from the bottom of the page, anterior focal distance of the eye ought to be 14,858 instead of 19,875.)

To solve the problem in a general way, I shall calculate the optical constants of a compound dioptrical system, consisting of the normal (or diagrammatical) eye combined with the series of our common spectacle-glasses. This work has not yet been done, and may also prove useful in solving other questions relating to vision through lenses.

In the calculations I shall avail myself of the convenient formulas given in *Helmholtz's* "*Physiologische Optik.*"

The usual distance at which spectacles are worn before the eye is about half a Paris inch. We may, therefore, place the auxiliary lens 14,858 mm. in front of the first principal plane of the eye. It is sufficiently accurate for

our present purpose to disregard the thickness of the glass lens, its two principal and focal points falling together and coinciding with the so-called optical centre. By placing the glass 14,858 mm. before the first principal plane of the eye, the optical centre of the first system coincides with the first focal point of the second system, the anterior focal length of the latter being 14,858 mm.

These suppositions made, we can proceed to *determine the position of the cardinal points of the compound system.*

f_1 and f_2 denote the first and second focal lengths* of the first system, which, being equal, may indiscriminately be represented by f.

ϕ_1 and ϕ_2 denote the first and second focal lengths of the second system, the eye;

And d the distance between the optical centre of the glass lens and the first principal plane of the eye.

$$d = 14{,}858 = \phi_1.$$

We find $a_1\, t_1$, viz., the distance of the first focal point of the compound system *in front* of the optical centre of the auxiliary lens by Helmholtz's formula 11*a* (l. c., p. 56).

$$a_1\, t_1 = \frac{(d - \phi_1)\, f_1}{d - \phi_1 - f_2}$$

d being equal to ϕ_1 and $d - \phi_1 = o$, we therefore obtain $a_1\, t_1 = o$,

* For the sake of simplicity of expression, I mean, in conformity with modern German opticians, by *focal length* always *principal focal length*, thus distinguishing it sufficiently from conjugate focal length or distance.

which signifies *that the anterior focal point of the compound system coincides with the anterior focal point of the eye.* This result is valid both for positive and negative glasses.

Formula 11*b*,

$$\alpha_2 \tau_2 = \frac{(d - f_2)\ \phi_2}{d - \phi_1 - f_2}$$

determines the position of the *second focal point of the compound system behind the second principal point of the eye.*

Let us illustrate the calculation by an example, say lenses No. 10, convex and concave, viz.: lenses with 270,6995 mm. of positive and negative focal lengths. By substituting the proper values, the preceding formula results in

$$\alpha_2 \tau_2 = \frac{(14,858 - 270,6995)\ 19,875}{-\ 270,6995} = 18,784 \text{ mm. for}$$

$+ 10''$,

and

$$\alpha_2 \tau_2 = \frac{(14,858 + 270,6995)\ 19,875}{270,6995} = 20,966 \text{ mm. for}$$

$-\ 10''$.

Both these values, being positive, indicate the situation of the posterior focal point of the compound system *behind* the posterior principal point of the eye.

I shall now proceed to determine the *principal points of the compound system.*

Formula 11*d* (Helmholtz, l. c., p. 57)

$$h_1 = \frac{d\,f_1}{d - \phi_1 - f_2}$$

determines the *position of the first principal point of the compound system in front of the first principal point of the first system.*

As $d - \phi_1 = o$, and $f_1 = f_2$, we obtain

$h_1 = -d.$

The same result is arrived at whether the auxiliary lens be positive or negative, since f_1 and f_2 will in either case have inverse signs, thus rendering the value of h_1 negative in both instances.

The negative sign before d means that the first principal point of the compound system does not lie *in front* of, but *behind* the first principal point of the glass lens. As we made $d = \phi_1$, it follows that *the first principal point of the compound system coincides with the first principal point of the eye.*

Formula 11*e* (ibidem, l. c.),

$$h_2 = \frac{d\,\phi_2}{d - \phi_1 - f_2},$$

determines the position of *the second principal point of the compound system behind the second principal point of the second system;* f_2 being assumed positive, that is a convex lens (+10) placed before the eye.

As $d - \phi_1 = o$, we obtain

$$h_2 = \frac{d\,\phi_2}{-f_2} = \frac{14{,}858 \times 19{,}875}{-270{,}700}$$

$$h_2 = -1{,}0909 \text{ mm.}$$

This result shows *that by placing a convex lens No.* 10

before the eye, the second principal point of the compound system falls 1,0909 *mm. in front of the second principal point of the eye.*—The distance between the two principal points of the eye being 0,4160 mm., this quantity subtracted from 1,0909 shows *the position of the second principal point of the compound system* 0,6749 *mm.* IN FRONT *of the first principal point of the compound system.*

We have determined above the position of the second focal point of the compound system to be 18,784 mm. behind the second principal point of the eye. To find the *second focal length*, which is the distance between the second principal point and the second focal point of the compound system, we must add 1,0909 mm. to 18,784 mm. Thus we obtain the second focal length of the compound system

$F_2 = 19,875$ mm., which is $= \phi_2$, the second focal length of the eye.

If we place a *negative lens* ($-10''$) before the eye, the second principal point is likewise obtained by formula 11*e*, with the difference only that f_2 being negative in this case, renders the value of h_2 positive, namely—

$$h_2 = \frac{d\,\phi_2}{d - \phi_1 + f_2} = 1,0909 \text{ mm.}$$

This shows that with negative glasses of the same focal length the second principal point recedes by the same quantity as it advances with positive glasses.

The second focal length of the compound system is,

therefore, obtained for concave glasses by subtracting this quantity from the value above found for $\alpha_2 \tau_2$, which expresses the distance between the second focal point of the compound system from the second principal point of the eye. Therefore,

$F_2 = 20{,}966 - 1{,}0909.$

$F_2 = 19{,}875 \text{ mm.} = \phi_2.$

Thus we have found *that the second focal length, F_2, of the compound system proves equal to the second focal length of the naked eye, whether for convex or for concave glasses.*

The position of the *nodal points* is now easily ascertained, as, in every system, the distance of the first nodal from the first focal point is equal to the second focal length. All these quantities of the compound system having been found identical with the corresponding quantities of the naked eye, the first *nodal point of the compound system must also coincide with the first nodal point of the eye.*

The equality of the posterior focal length of the compound system with that of the eye, has been obtained only by numerical calculation of one example, and from it the position of the first nodal point has been deduced. As this may not be considered sufficient evidence, I shall demonstrate it in a general way.

Formula 11*d*,

$$h_1 = \frac{d\ f_1}{d - \phi_1 - f_2},$$

determines the position of the first principal point by the

distance (d) of the glass lens from the anterior principal point, moreover by the anterior focal length (ϕ_1) of the eye, and the focal length of the glass ($f_1 = f_2$). The position of the focal points of a compound dioptrical system may be determined independently from the principal points, by proceeding from the nodal points of the single systems in a similar way as by making use of the principal points. If d' signifies the distance between the second nodal point of the first system and the first nodal point of the second system, ϕ_2 the second focal length of the second system, and f_1 and f_2 the anterior and posterior focal lengths of the first system, the formula 11d is transformed into the following:

$$K_1 = \frac{d' f_1}{d' - \phi_2 - f_2}$$

in which K_1 represents the situation of the anterior nodal point of the compound system *in front* of the anterior nodal point of the first system.

$d' = \phi_2$ and $f_1 = f_2$, we obtain

$K_1 = - d' = \phi_2$, that is, the anterior nodal point of the compound system lies *behind* the optical centre of the glass lens by a quantity equal to the posterior focal length of the eye, and, therefore, coincides with the first nodal point of the eye. Since the anterior focal point of the compound system likewise coincides with the anterior focal point of the eye, it follows that the posterior focal length of the compound system equals the posterior focal length of the eye.

If, instead of a convex lens, we place a concave one before the eye, these results remain the same, for f_1 and f_2, which now are negative, enter into the above formula with inverse signs, consequently the value and situation of K_1 will not be influenced.

The distance between the two nodal points being always, in every simple or compound system whatsoever, equal to the distance of the two principal points, *the second nodal point of our compound system must assume the same position relative to the first nodal point, as the second principal point to the first principal point of the compound system.*

Since, lastly, the second focal length of the compound system is the distance between its second principal and second focal points, and is equal to the second focal length of the eye, it is evident that *the second focal point of the compound system takes the same relative position to the second focal point of the eye, as the second principal and nodal points of the compound system to the second principal and nodal points of the eye.*

If we recapitulate the foregoing investigations, we notice the following remarkable result :—

Spectacle-glasses, held half an inch before the eye, do not change the situation of its anterior cardinal points, nor its anterior and posterior focal lengths, but the situation of each of the posterior cardinal points is altered in such a manner that convex lenses make them advance, and concave glasses recede by the same quantity.

Having arrived at this conclusion, our practical calcu-

lations are very much simplified, and, indeed, reduced to the evaluation of the position of either the second principal or second nodal point. This indicates at the same time what change has taken place in the position of the posterior focal plane, that is, the retina, and, consequently, in *the length of the ocular axis.*

After having, in this way, determined the *optical constants* of a compound dioptrical system, consisting of *the human eye and spectacle-glasses*, we may now proceed to investigate *what influence the latter have on visual acuteness.*

The *sharpness of vision in the normal eye is dependent on the density of the percipient retinal elements.* We may fairly assume that the number of these percipient retinal elements, and of the optic-nerve fibres connected with them, is the same in all normal eyes. If, nevertheless, we find variations of S in different eyes which we must consider as normal, these variations result certainly more from deficiencies in the optical part of the eye than from varying numbers of percipient elements and optic nerve-fibres. In diseased eyes, where the optic nerve, retina, and choroid have suffered, the sharpness of vision sinks in proportion to the destruction of percipient elements. *According to general acceptance, S is measured by the smallest visual angle, that is, the deviation of two lines which connect the second nodal point of the eye with two adjoining percipient retinal elements.* Hence it follows that the visual angle, and with it S, will change whenever the distance between the second nodal point and the retina changes,

the latter itself undergoing no alteration of structure. Spectacles move, as we have seen, the second nodal point, and therefore change the visual angle; but only in a few instances, viz., in presbyopia, and if the effect of weak glasses is counterbalanced by accommodation, we have to deal with normal eyes. The eyes which require spectacles in order to see at distance clearly and with ease, that is, without any accommodative effort, are not normal, but either too long (myopia), or too short (hyperopia). Since, however, as we have said at the beginning, the refractive parts of these eyes are normal, the shortening or elongation of the ocular axis can only result from advancement or retrocession of the posterior portion of the ocular membranes. The retina of such eyes may be, and mostly is, as normal as in the emmetropic eye, and therefore must contain the same number of percipient

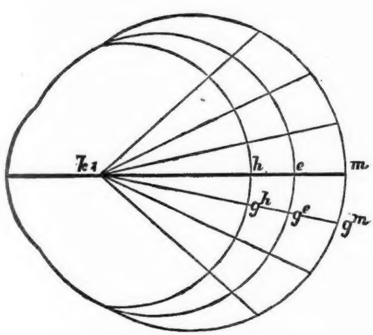


FIG. 1. $\frac{2}{1}$.

elements and nerve-fibres. The necessary consequence of this fact evidently is, that the absolute density of the

retinal elements is greater in short (hyperopic), and less in long (myopic), than in emmetropic eyes. In hyperopic eyes, the retinal surface, with all its elementary parts, may be considered as contracted, in myopic eyes, as expanded. If, in Fig. 1, the three curved lines represent a hyperopic, emmetropic, and myopic eye, the radii drawn from the anterior nodal point (k_1), will embrace between them corresponding portions of the retina, with equal numbers of percipient elements. The same number of the latter which exists in the normal eye must be distributed over a smaller surface in the hyperopic eye, and over a larger surface in the myopic eye.

Let us now see *what influence spectacles exert on visual acuity.* Fig. 2 will illustrate this very plainly. *A B*

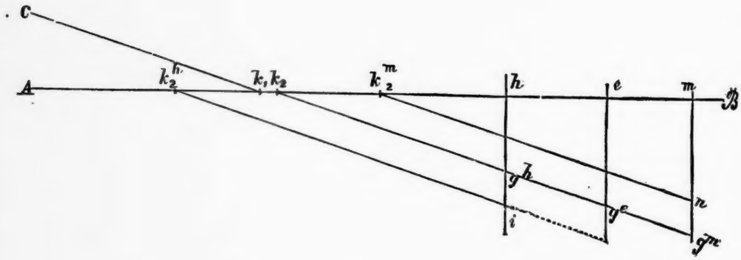


FIG. 2.

is to represent the visual line, k_1 and k_2^e the anterior and posterior nodal points, and *e* the intersection of the retina and the visual axis in the emmetropic eye. *h* and *m* are the points of intersection of the visual line and

retina, k_2^h and k_2^m the posterior nodal points in the hyperopic and myopic eyes, thus displaced by spectacles neutralizing the errors of refraction.

If the same object be looked at by each of the three eyes, it will appear under the same visual angle. This statement is at variance with the current opinion, that convex glasses, by advancing the nodal point, render the visual angle larger, and concave glasses render it smaller by making the nodal point recede. This would be true if both nodal points coincided, or were displaced, by spectacles in the same direction. In the naked eye they lie indeed close together, and during accommodative efforts their movements are homonymous, so that they may, for ordinary purposes, be regarded as coinciding. But for eyes armed with spectacles we are no longer allowed to make this concession, as I have shown above. Let, in Fig. 2, $A\,k_1$ represent the principal line of direction (principal axial ray of authors) of an object, Ck_1 a secondary line of direction (secondary axial ray), then the former will continue its course undeviated, while the latter will pass through the vitreous body parallel to its anterior portion (going through the air), but be displaced in such a way that the second nodal point (k_2^e) lies in the naked eye very little behind the first (k_1), further behind (k_2^m) in an eye armed with concave glasses, and in front of the second nodal point of the unarmed eye in eyes wearing convex glasses (k_2^h). If we consider (in Fig. 2) the different triangles which are formed by the primary and secondary lines of direction,

and the connecting lines of their crossing points in the retina, we see that all these triangles are similar to one another, and especially *the angles at* k_2, *the visual angles, are equal.*

When the *hyperopic eye* is not armed with spectacles, its retina, *hi*, is situate in front of its posterior focal plane, eg^e, but its posterior nodal point, k_2^e, lies in the normal place. The secondary visual line cuts off the portion hg^h of the retina. But when the hyperopic eye is armed with convex spectacles, the secondary nodal point advances (k_2^h), and the secondary axis cuts off, on the retina, a larger portion, *hi*, than it did before spectacles were added to the eye. The larger portion of retina must, of course, comprise a greater number of percipient elements. If we now admit that in Figs. 1 and 2 eg^e are two adjoining percipient elements of the retina, being approximated to each other, in the hyperopic eye, to the position hg^h, then we see that the addition of a convex glass causes, of the same object, a larger retinal image than the naked eye. If hg^h represents the extent of the smallest perceptible retinal image, say f. i. of No. xx. Snellen, seen at 20′ distance, the addition of a convex glass, increasing the retinal image of the same object to the extent of *hi*, would enable the same eye to distinguish at 20′ distance smaller type than No. xx. Sn. Thus we find its visual acuteness greater than $\frac{20}{xx}$, or $S > 1$. It is, therefore, evident that by wearing convex glasses the optical power of the eye increases, even if we leave out

of consideration the correction of the impurity of the retinal images.

Suppose somebody is able *to see at distance distinctly without and with convex glasses* (facultative hyperopia, *Donders*), then his eye, when unaided, would form the perfectly pure image hg^{h}, and, when armed with a convex glass, the image *hi* quite as distinctly, but larger, of the same object. Therefore the eye, when armed with convex glasses, would be able to read smaller type than Sn. xx. at 20′ distance, that is, his visual acuteness would be greater than normal, according to our usual method of testing.

Both nodal points advance in every eye by accommodation. By $A = \frac{1}{4}$ this advancement amounts to 0,4 to 0,5 mm., causing an adequate aggrandizement of the retinal images equivalent to that produced by convex spectacles No. 24, as the table further below demonstrates. In this way we are able to compare the aggrandizement of the image caused by accommodation in the unarmed hyperopic eye, with the aggrandizement of the image caused by convex glasses in the hyperopic eye. To determine how much the magnifying effect of convex glasses exceeds that produced by accommodation, we take the former in the table further below, and deduct from it the aggrandizement produced by accommodation. If, f. i., a patient with hyperopia $= \frac{1}{12}$ wishes to see clearly at distance without glasses, he must make an accommodative effort of $\frac{1}{12}$. But this is only the third part of $A = \frac{1}{4}$; the aggrandizement by accommodation, therefore,

is only one-third of that produced by a convex glass No. 24, or equivalent to that of + 72. We shall, hereafter, see that the magnifying effect of glasses weaker than No. 10 may fairly be neglected for practical purposes; so much the more may we disregard the influence of accommodation on the size of the retinal images. Apart from that, it is the object of the present investigation to evaluate the changes of size brought about by spectacles in the retinal images, making abstraction of the optical purity of the latter. In that way only we obtain a correct measure to compare the visual acuteness of armed ametropic eyes with that of the unarmed emmetropic eye; for spectacles re-establish the purity of the retinal images, and render accommodation equal to that of the emmetropic eye; but in doing so they moreover exert some influence on the size of the retinal image, and it is the amount and consequences of this accessory factor we are endeavoring here to ascertain. The foregoing lines, however, solve the problem raised by *Donders*, and quoted at the beginning of this paper, that a comparison of the visual angles can only be made, if the visual object can be accurately seen with or without auxiliary glasses. Instead of visual angles we would now say the size of the retinal images.

The conditions of *myopic eyes* are easier to analyze. The retina, mg^m, Figs. 1 and 2, being distended, displays a less density of its percipient elements. The line mg^m may be supposed, as I have shown, to contain no more percipient elements than eg^e or hg^h in the emmetropic

and hyperopic eyes. If, now, mg^m (Fig. 2) is the smallest perceptible retinal image of an unaided myopic eye, the addition of a concave glass would reduce this image of the same object to the size of *mn*, by shifting the second nodal point from k_2^e backward to k_2^m. The dimension *mn* being less than the distance of two adjoining percipient elements, or less than the smallest perceptible retinal image, the addition of a concave glass has rendered visual acuteness less than normal.

The amount of increase or diminution of visual acuteness brought about by spectacles is proportionate to the increase or diminution they produce in the retinal images. This amount may be estimated as follows:

(*A.*) *Calculation of the amount of increase of the retinal image, and, consequently, of visual acuteness by convex glasses.*

Let $hg^h = \beta_1$, Fig. 2, be the linear dimension of a smallest retinal image of an hyperopic eye, and $hi = \beta_2$, the retinal image of the same object in the same distance when looked at through a convex glass, then β_1 and β_2 constitute corresponding lines in two similar triangles, and are to each other as their distances from the corresponding nodal points. The quantity by which the second nodal point is shifted on the axes may be called $\delta = k_2^e\, k_2^h = k_2^e\, k_2^m$, then $hk_2^e = F_1 - \delta$, since the distance of the second nodal point of the compound system from the retina is equal to the first focal length of the eye, $hk_2^h = F_1$. We therefore obtain the following proportion:—

$$\frac{\beta_2}{\beta_1} = \frac{F_1}{F_1 - \delta},$$ from which is deduced

$$\beta_2 = \frac{\beta_1 \, F_1}{F_1 - \delta}.$$

If we give β_1 the standard value 1, we obtain

$\beta_2 = \frac{F_1}{F_1 - \delta}$ as the amount of β_2 with regard to β_1.

F_1 being 14,858 mm., and $\delta = 1{,}0909$ mm. (for + 10 as we saw above), we obtain

$\beta_2 = 1{,}0793$, *as the co-efficient of any retinal image, when + 10 is worn half an inch before the eye.*

If we measure visual acuteness by the smallest perceptible retinal image, and assume the hyperopic eye had S = 1, it will have S = 1,0793 when armed with + 10.

Since the linear dimension of the retinal image is in simple inverse proportion to the distance of the object, that is, decreases as the object is removed, Sn. xx. must be 1,0793 × 20′ = 21,580′ removed from an eye armed with + 10 in order to produce the smallest perceptible retinal image.

(*B.*) *Calculation of the amount of diminution of the retinal image, and, consequently, the visual acuteness, by concave glasses.* In the unaided myopic eye the second nodal point lies in the same place as in the emmetropic eye, k_2^e Fig. 2. Since the retina is distended proportionately to its retrocession, the retinal elements contained in the line eg^e of the emmetropic eye are distributed over the longer line mg^m of the myopic eye. The retrocession of the second nodal point from k_2^e to k_2^m, resulting from the ad-

dition of a concave glass before the eye, generates from the same object which in the unaided myopic eye produced the image mg^m, now the smaller image mn. The relation of magnitude of both these images is easy to ascertain. $m\,k_2^m$ is equal to $F_1 = 14{,}858$ mm., and $k_2^m\,k_2^e = \delta$ is the retrocession of the second nodal point, amounting for a glass of 10″ of negative focal distance to 1,0909 mm. If $mn = \beta^2$, and $mg^m = \beta_1$, the similarity of the respective triangles shows

$$\frac{\beta_2}{\beta_1} = \frac{F_1}{F_1 + \delta} = 0{,}9316,$$

which expresses the co-efficient of the diminishing power of concave 10″.

A myopic eye, armed with −10″, therefore, must be considered to possess normal acuteness of vision, if it is able to read Sn. xx. at 0,9316 × 20′ = 18,632′.

I have disregarded, in the foregoing investigations, the appearance of dispersion circles, and was certainly justified to do so, because I founded the visual acuteness on the density of the percipient retinal elements and the *dimensions* of the retinal images, making abstraction of all imperfections of the latter. If an unaided ametropic eye looks, with relaxed accommodation, at a distant object, the centres of the dispersion circles from the end-points of the object will fall on the same retinal elements as in the emmetropic eye, as is illustrated in Fig. 2 ; g^h, g^e, and g^m are the same retinal elements, that is, they are separated from the central element of the fovea centralis (h, or e, or m) by an equal number of intermediate elements. If

$e\,g^e$ are two adjoining retinal elements, then hg^h and mg^m are likewise adjoining.

The addition of spectacles to the eye has the effect of shifting the second nodal point on the axis. Hence the images of all the object points, except the one situate in the axis, are displaced, namely, removed from the axis by convex glasses, approximated to it by concave glasses. Thus it is evident that convex glasses cause the image of an object to cover a greater number of percipient retinal elements than if the same object were seen without glasses, whilst the inverse obtains with concave glasses. I have shown already that it is erroneous to speak, as it is generally done, of an augmentation or diminution of the visual angle by spectacles, for the visual angle remains unchanged, if glasses are worn at the usual distance of half an inch from the eye.

I have now, in a general way, solved the problem to show what influence spectacles have on the optical constants of the eye, on the size of the retinal images, and on the acuteness of vision. I have, moreover, illustrated it by an example, No. 10 convex and concave.

To render these investigations useful for reference, I shall tabulate the results of calculation concerning the series of our test-glasses :—

Number of glass in Paris inches.	Displacement of 2d cardinal points in millimetres.	Co-efficient of magnifying effect of convex glass.	Co-efficient of diminishing effect of concave glass.	S being 1, No. xx. Sn. should be read with convex glass in Paris feet.	S = 1, No. xx. Sn. should be read with concave glass in Paris feet
30	0,3628	1,0250	0,9762	20,50	19,52
16	0,6812	1,0480	0,9562	20,96	19,12
10	1,0909	1,0793	0,9316	21,59	18,63
8	1,3636	1,1011	0,9159	22,02	18,32
7	1,5584	1,1171	0,9051	22,34	18,10
6	1,8182	1,1396	0,8910	22,79	17,82
5	2,1818	1,1721	0,8720	23,44	17,44
4	2,7272	1,2248	0,8449	24,45	16,90
3½	3,1168	1,2655	0,8265	25,31	16,53
3	3,6363	1,3240	0,8034	26,48	16,07
2½	4,3636	1,4159	0,7738	28,32	15,48
2	5,4544	1,5800	0,7315	31,60	14,63
1¾	6,2499	1,7260	0,7078	34,52	14,08
1½	7,2914	1,9625	0,6708	39,25	13,42
1¼	8,2602	2,3044	0,6427	46,09	12,85
1	10,909	3,4878	0,5837	69,77	11,67

Remarks on the foregoing Table.

The displacement of the second cardinal points, that is, the second principal, nodal, and focal points, expresses at the same time the elongation or shortening of the ocular axis in degrees of ametropia corresponding to the number of the spectacle-glasses enumerated in the first column. The length of the ocular axis, that is, the distance between the apex of the cornea and the fovea centralis retinæ, in the normal eye, is 22,23 mm., according to *Listing's* diagram. We may, therefore, avail ourselves of this table to determine, with the ophthalmoscope or functional testing, the situation of any part of the fundus oculi with regard to the position of the posterior

focal plane. If, for instance, a tumor or a circumscribed exudation projects over the background of the eye, we have first to ascertain with which auxiliary glass, put behind the ophthalmoscope, we can see clearly, by relaxed accommodation and in the upright image, the background of the eye, and, secondly, with which other glass we can see the summit of the projection. The difference of both glasses will give the height of the elevation by referring to the first and second columns of our table. Since this evaluation is of importance in judging the existence and amount of any elevation or depression, as well as its augmentation or diminution during the course of the disease, I shall illustrate the manner of this ophthalmoscopic measurement by some examples.

1. In an emmetropic eye, the fundus of which an emmetropic observer sees distinctly without any auxiliary glass put behind the ophthalmoscope, and an ametropic observer with his neutralizing glass, there is a circumscribed exudation or tumor, the summit of which is distinctly seen in the erect image with all the convex glasses up to number 8, whilst with stronger glasses it appears indistinct. Then No. 8, the strongest convex glass with which the summit of the tumor appears distinct, indicates an elevation of the tumor by 1,36 mm. over the background of the eye, as is seen by the number of the second column of the above table corresponding to No. 8.*

* I have described this method of estimating the relief of the background of the eye at the meeting of the Société Universelle d'Ophthalmologie, Aug., 1867, in Paris, and given a table relating to it in my book on "Intraocular

2. The fundus oculi is seen with + 24 distinctly, the summit of a tumor with + 4. The height of the tumor is calculated as follows: $\frac{1}{4} - \frac{1}{24} = \frac{5}{24}$, or nearly $\frac{1}{5}$. No. 5 in the first column of the above table indicates, as seen in the second column, an elevation of 2,18 mm. over the level of the retina.

3. The fundus is seen distinctly with − 20; the summit of a tumor with + 10. $\frac{1}{10} + \frac{1}{20} = \frac{3}{20} = \frac{1}{6\frac{2}{3}}$ gives, with reference to columns the first and second, 1,66 mm. as the height of the tumor.

4. A hyperopic eye, the retina of which appears distinct with + 6, suffers from chronic glaucoma. The area of the optic disc appears plain with + 18. How deep is the excavation? $\frac{1}{6} - \frac{1}{18} = \frac{1}{6}$. Answer: 1,2 mm. This method of estimating elevations and depressions is especially valuable in the early stages of new growths and excavations, when the differential diagnosis and our judgment with regard to the progressiveness of the morbid action are apt to be difficult.

The *third and fourth columns* of the above table do not require much explanation. Each glass of the first column,

Tumors," p. 106. The numbers there were obtained by another way of calculation, and differ slightly from those given in this paper, because I took as basis of the former calculation the results of my own measurements on the living eye, whilst for the calculation of the present table the values of *Listing's* diagrammatic eye are taken as basis. I have here preferred *Listing's* values, although they are perhaps not so generally correct as those obtained on the living eye, because they are at the reach of everybody, and the difference between the two is unimportant. Dr. *Mauthner* also describes the measurement of the depth of the background of the eye in his Treatise on Ophthalmoscopy, Vienna, 1868. He gives some examples, but no table to refer to.

by displacing the second nodal point, produces a certain alteration of the size of the retinal images. This alteration is found by multiplying the linear dimensions of the retinal images with the corresponding numbers of the third and fourth columns. Therefore I have called them *co-efficients* of the magnifying or diminishing effect of spectacles.

The *fifth and sixth columns* need not much explication either. Snellen's test-types being so chosen that the size of the letters or the intervals between them produce, at the distance indicated by their numbers, the smallest perceptible retinal images, then by looking with spectacles, on account of their magnifying or diminishing power, the distances of the types from the eye must be changed, if the images are to remain the smallest possible for distinct perception. We find the requisite distance for each number of Snellen's test-types, and for each spectacle-glass, by multiplying the number of the type with the co-efficient of magnifying or diminishing power of the glass. This having been done for No. xx with the series of test-glasses, the fifth and sixth columns give a comprehensive statement of the influence of spectacles on the acuteness of vision. We see that spectacles weaker than number ten have but a slight influence on the distance in which the different types should be read, so that we may fairly neglect it. Stronger glasses than No. 10 have a notable influence on the distance in which the type ought to be read. This influence, however, is not so great as might perhaps be an-

ticipated, since of strongest convex glasses No. 2 requires only one and a half of the distance indicated by the number of type, No. 4 nearly $\frac{5}{4}$ of it, etc., whilst concave glasses No. 2 require only $\frac{3}{4}$ of the distance stated in the number of type, in order to let visual acuteness appear normal.

I think it is not practical to change anything in our accustomed annotations of visual acuteness. But when it is of importance to judge exactly of the acuity of vision, we may refer to the above table which will in a moment give us the correction to be made in our annotations. Say, for instance, a myopic eye can read with number two Sn. xx at 15′, then we would note it as follows: $M\frac{1}{2}$, $S\frac{15}{xx}$. A look at column the sixth of our table will show us immediately that S in this case is not $\frac{3}{4}$, but 1. The use of the table for reference appears to me so simple, that I think it unnecessary to give any further examples.

(B.) INFLUENCE OF SPECTACLES ON THE APHAKIAL EYE.

The optical system of the *aphakial eye*—which means an eye whose crystalline lens has been removed, or dislocated, or absorbed—is essentially different from that of the emmetropic eye. As clear vision in aphakial eyes can only be brought about by the help of strong convex glasses, I shall now proceed to investigate what influences such glasses exert on the optical system and visual acuteness of aphakial eyes. In noting, at the present day, the results of our cataract-operations, we

do no longer content ourselves by the general expressions that good or useful vision was obtained, or even that sight was regained, but we test the acuteness of vision in quite as rigid a manner as we do in ordinary eyes. To know the alterations which spectacles produce in aphakial eyes, is, therefore, not merely of theoretical, but of practical interest.

I shall determine the optical constants of armed aphakial eyes in the same manner as I did those of armed emmetropic eyes.

The *optical constants of the unarmed aphakial eye* which constitute the second system, are the following:–

ϕ_1, the first focal distance, is = 23,692 mm.

ϕ_2, the second focal distance, = 31,692 mm.

Both the principal points coincide, and are situate in the apex of the cornea.

Both the nodal points coincide likewise, and are situate in the centre of curvature of the anterior surface of the cornea, namely, 8 mm. behind its apex.

These values are borrowed from *Listing's* diagrammatic eye, in conformity with our former inquiries into the optical constants of armed emmetropic eyes. The first optical system is represented by the convex glass lens, the principal and nodal points of which, here too, may be assumed with sufficient accuracy to coincide with its optical centre. We admit that the latter is placed 12 mm. in front of the eye. This, therefore, is the mutual distance—called *d*—of the principal points of the first and second systems.

Helmholtz's formula 11*d*, $h_1 = \frac{d\,f}{d - \phi_1 - f}$, will serve to calculate the position of the first principal point of the compound system in front of the first principal plane of the first single system. Applied to lens + 3, that is, of 81,21 mm. of positive focal distance, it will result in

$$h_1 = \frac{12 \times 81{,}21}{12 - 23{,}692 - 81{,}21} = - 10{,}485 \text{ mm.},$$

which means that the first principal point of the compound system lies 10,485 mm. *behind* the glass. Since the latter is placed 12 mm. in front of the cornea, the first principal point of the compound system lies 1,515 mm. in front of the cornea.

Formula 11*e*, $h_2 = \frac{d\,\phi_2}{d - \phi_1 - f}$, determines the position of the second principal point of the compound system behind the cornea. It results for lens + 3 in $h_2 = - 4{,}0917$ mm. The − sign signifies that h_2 lies in front of the cornea, and, as follows from the position of h_1, 2,5767 mm. before the first principal point of the compound system. The latter number denotes at the same time the distance between both the principal points, therefore also that between both the nodal points of the compound system. For lens + 3, therefore, $H_1 H_2 = K_1 K_2 = 2{,}5767$ mm.

The position of the *first focal point* of the compound system in front of the optical centre of the glass lens is obtained by formula 11*a*, $a_1 t_1 = \frac{(d - \phi_1)\,f}{d - \phi_1 - f}$. For lens + 3 this is found by calculation =10,216 mm. If we add 12

mm. as the distance of the glass from the cornea, we obtain the position of the first focal point of the compound system in front of the cornea, namely, 22,216 mm. Since, however, the first focal length is reckoned from the first principal point, we must deduct 1,515 mm. from that quantity, and we obtain the anterior focal length of the compound system $F_1 = 20{,}701$ mm.

The position of the *posterior focal point* behind the second principal plane of the second system—in our case the anterior surface of the cornea—is determined by formula 11*b*, $\alpha_2\, t_2 = \frac{(d - f)\, \phi_2}{d - \phi_1 - f}$. By inserting the proper values, we find for lens + 3 $\alpha_2\, \tau_2 = 23{,}599$ mm. It is evident that this number represents at the same time the length of the AXIS OF AN APHAKIAL EYE which sees at distance best with + 3. As, however, the posterior focal length is measured, not from the cornea, but from the second principal point, we must add to this quantity 4,0917 mm., the distance in which the second principal point of the compound system is situate in front of the cornea. Thus we obtain $F_2 = 27{,}691$ mm.

The positions of the two *nodal points* of the compound system are easily found out by the following considerations:—The distance between the second nodal and the posterior focal points is equal to the first focal length. Therefore $F_2 - F_1 = H_2\, K_2$, that is, the distance between the second principal and second nodal points, which is also equal to $H_1\, K_1$, the distance between the first principal and first nodal points. For lens + 3 $H_1 K_1$, or $H_2 K_2$, is equal

to 6,990 mm. Since the first principal point lies 1,515 mm. before the cornea, we must deduct this quantity from 6,990, to find the position of the first nodal point behind the cornea. We obtain 5,475 mm. The position of the second nodal point is found in a similar way by deducting from 6,990 mm. the distance of the second principal point from the cornea, which amounts to 4,092 mm. We obtain K_2 lying 2,898 mm. behind the apex of the cornea.

In this way all the optical constants of an aphakial eye armed with + 3 are determined.

Let us now inquire *what influence spectacle glasses exert on the visual acuteness of aphakial eyes.*

We assume that the eye, before it was deprived of its crystalline lens, possessed normal visual acuity. The position of its retina, that is, the length of its antero-posterior axis, can be determined, after its lens has been removed, by formula 11*b*, as we have seen. Since we know the optical constants in the aphakial state, we can calculate the

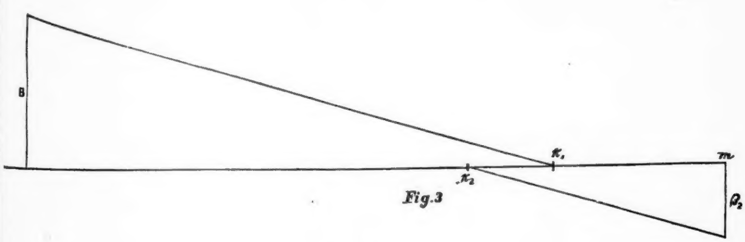


FIG. 3.

size of the retinal image of any visual object. B, in Fig. 3, may represent a small remote object which the apha-

kial eye, armed with + 3, is able to see distinctly. The one of its end-points may be situate on the optical axis of the eye. The line of direction of its other end-point is, in its course through the air, directed to the first nodal point K_1, and passes, in its course within the vitreous body, through the second nodal point K_2, while remaining parallel to its first section in the air. Thus the retinal image β_2 is defined. If we now imagine the same eye to be still in possession of its normal crystalline lens, we may draw in it the retinal image of the same object seen in the same distance. Since cornea and lens are assumed to be normal, the optical constants of *Listing's* diagrammatic eye may be used for the determination of the retinal image. Fig. 4 may illustrate this. To find out the

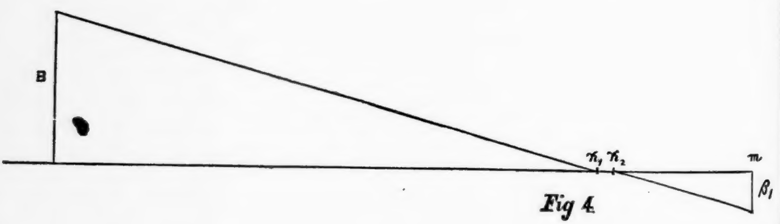


FIG. 4.

magnifying effect of the glass lens, we have to compare the sizes of the retinal images β_2 and β_1 formed, in both eyes, of the same object B. The triangles formed by the retinal images and their connecting lines with the posterior nodal points being similar to each other, the sizes of both images are to each other as their distances from the

second nodal points. $\frac{\beta_2}{\beta_1} = \frac{\text{m K}_2}{\text{m } \varkappa_2}$. If we attribute to β_1 the value 1, then $\beta_2 = \frac{\text{m K}_2}{\text{m } \varkappa_2}$. The quantity mK_2 is known, and equal to the anterior focal length F_1 of the lensless eye when armed with + 3. The quantity $\text{m}\varkappa_2$ may be called ϕ, and determined as follows. We found the axis of this eye equal to 23,599 mm. The posterior nodal point is situate 7,373 mm. behind the cornea. ϕ, therefore, is equal to $23{,}599 - 7{,}373 = 16{,}326$ mm. We obtain, consequently, $\beta_2 = \frac{F_1}{\phi} = \frac{20{,}701}{16{,}326} = 1{,}2758$. This is what we have called the co-efficient of the magnifying effect of the glass lens. The distance at which any number of Snellen's test-types ought to be read by a lensless eye, when armed with + 3 and endowed with normal visual acuteness, is obtained by multiplying this co-efficient with the number of the type, for instance, No. xx should be read in $20 \times 1{,}2758 = 25{,}52$ feet.

In this consideration we have presupposed that the lines of direction emanating from the end-points of the same object, which has to remain at the same distance, are parallel, and this supposition may be made with sufficient accuracy. The letters of Sn. xx are 9,5 mm. high, they are seen at a distance of 20′, that is, 6496,9 mm. The first nodal point of the emmetropic eye lies 6,957 mm. behind the cornea, that of the aphakial eye, when armed with +3, lies 5,475 mm. behind the cornea. If from an elevation of only 9,5 mm. above a straight

basal line, other straight lines are drawn to two points of the same basal line at a distance of 6497 mm. from the point of origin, and only 0,3 to 3,0 mm. from each other, these lines will be sufficiently parallel to each other for all ordinary purposes. To satisfy myself of this fact, I have calculated the visual angles formed in emmetropic eyes and armed aphakial eyes by letters of Sn. xx seen at 20′. If we call the visual angle v, its tangent will be, in the emmetropic eye, $\frac{9,5}{9503,9}$, and in an aphakial eye, when armed with +4, = $\frac{9,5}{6503,0}$. The logarithms of the tangents of these angles differ only in the fifth decimal, and show in both cases an angle of five minutes. This angle remains the same also for the strongest lens, + 1½, that may ever be put before an aphakial eye. The logarithms of the tangent of its visual angle and that of the emmetropic eye differ by 0,00022, whilst the difference of the logarithms of the tangents of an angle of 5 minutes and 0 second, and those of an angle of 5 minutes and 1 second is 0,00134. From the foregoing considerations it ensues *that the movement of the first nodal point by spectacle glasses exerts no appreciable influence on the size of the smallest visual angle* as used in our common test-types, since its greatest movement, produced by + 1½, causes a change in the size of the visual angle not exceeding ⅙ of a second.

Thus far I have shown, in a general way, and illustrated by an example, what alterations are brought about in the optical system of aphakial eyes armed with spec-

tacles. I have demonstrated, moreover, what influence spectacles have on visual acuteness when the latter is tested in the manner now in general practice. Since both the changes of the optical constants and of visual acuteness deserve to be known, I have calculated them for the usual cataract glasses; and collected them, for the sake of reference, in the subsequent table.

The letters at the heads of the columns have the following meaning:—

No = focal length of glass in Paris inches.

F_1 = first focal length of aphakial eye armed with lens named in first column.

F_2 = second focal length of compound system.

Ax = Axis of aphakial eye requiring for distant vision lens indicated in first column.

$H_1 K_2$ = distance between first principal and first nodal points.

$H_1 H_2 = K_1 K_2$ = mutual distance of principal or nodal points.

H_1 = position of first, and H_2 of second principal point behind the cornea. A − sign indicates that they lie before the latter.

K_1 and K_2 = position of first and second nodal points behind the cornea.

Co-ef. = Co-efficient of magnifying power.

Sn. xx *in feet*, at what distance, in Paris feet, Sn. xx should be read when S = 1.

No.	F_1.	F_2.	Ax.	$H_1 K_1$.	$H_1 H_2$.
1½	18,300	24,596	17,324	6,296	4,536
1¾	19,080	25,525	19,193	6,445	3,996
2	19,485	26,063	20,286	6,578	3,646
2½	20,202	27,024	22,232	6,802	3,024
3	20,701	27,691	23,599	6,990	2,577
3½	21,089	28,210	24,637	7,121	2,254
4	21,384	28,605	25,435	7,221	2,001
5	21,809	29,172	26,586	7,363	1,632
6	22,113	29,565	27,381	7,452	1,389

No.	H_1.	H_2.	K_1.	K_2.	Co-ef.	Sn. xx. in feet
1½	— 2,736	— 7,2720	3,560	—0,976	1,8390	36,78
1¾	— 2,336	— 6,3316	4,109	0,113	1,6149	32,30
2	— 2,131	— 5,7769	4,447	0,801	1,5124	30,25
2½	— 1,768	— 4,7917	5,034	2,010	1,3595	27,19
3	— 1,515	— 4,0917	5,475	2,898	1,2758	25,52
3½	— 1,318	— 3,5730	5,803	3,549	1,2216	24,43
4	— 1,169	— 3,1700	6,052	4,051	1,1839	23,68
5	— 0,954	— 2,5864	6,409	4,777	1,1351	22,70
6	— 0,795	— 2,1843	6,657	5,268	1,0801	21,60

LARGE CYST OF THE IRIS, CURED BY OPERATION.

By H. KNAPP.

THE literature of cystic tumors of the iris is yet very fragmentary. *J. W. Hulke* (Ophth. Hosp. Rep., Vol. VI., 1, p. 12) and *L. Wecker*, in his Études Ophthalmologiques (I., p. 426), and in a paper in these Archives (I., 1, p. 85), have given the fullest accounts of what is known on this subject. Since especially the clinical part of cystic tumors originating in the iris is as yet most defective, I think that the description of the following case may not prove destitute of interest and practical utility.

Cecile *Delahaye*, from Burlington, Iowa, eleven years of age, was injured, eighteen months ago, with a knife, the point of which entered her left eye just at the corneo-sclerotic juncture. The pupil became pear-shaped, the sight, for some days impaired, returned nearly as good as that of the other eye. A black, elevated spot at the seat of the wound was always visible. The eye was free from pain and annoyance. Eight months ago, however, the father observed that a thin gray membrane had formed in the eye directly under the scar, and was grad-

ually increasing in the direction of the pupil. Four months ago he perceived that a similar membrane developed itself on the other side of the pear-shaped pupil. Both were growing steadily, and slowly approached each other, until they coalesced, assuming a heart-shaped figure. The sight had been impaired, and the eye, of late, became from time to time red and painful.

The patient, a tall healthy girl, presented herself to me on the 31st of May, 1869. Her right eye was normal in appearance and functions, and had never experienced any alteration. The left showed some episcleral injection, most marked towards the nose. On the sclerotic border, a little inward from the upper end of the vertical corneal meridian, was a small bluish elevation of three millimetres in length and two millimetres in breadth (*a* Fig. 5). Through the normal cornea a

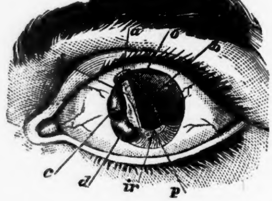


FIG. 5.

transparent cyst was, at first glance, visible, filling the upper four-fifths of the anterior chamber. It left a small piece of healthy iris, on the lower part of the chamber

(*ir*), uncovered, and about a quarter of the normal size of the pupil was free and perfectly black (*p*).

The *cyst itself* appeared as a transparent, homogeneous, somewhat grayish bag, filled with clear water. The coloboma and iris could be seen through it. The whole anterior surface of the cyst appeared to be in immediate contact with the cornea, whilst its inferior border was round, and formed an angle in the pupil (*a*). Its upper and outer part lay upon the iris, which it pushed backward (*b*). The surface of this part of the iris, visible through the cyst, displayed a grayish discoloration, but was smooth, with quite a regular pupillary edge. On the upper corneal margin there existed a small, slit-shaped iridodialysis (*o*, Figs. 5 and 6). Entirely different was that portion of the iris bordering on the inner side of the coloboma. It was very much pushed backward, and showed two cup-like depressions (*c*, *d*), each of which was confined, inferiorly, by a curved projecting ridge of iris tissue. The lower of them formed the boundary of the preserved healthy part of the iris. The surface of the depressed portion of the iris appeared dirty gray, and even black in the upper part, which also exhibited the deepest cup. The pupillary edge was elevated, forming, along the whole inner border of the coloboma, a septum (*s*) with antero-posterior direction slightly bulging towards the coloboma. Its margin did not reach the posterior surface of the cornea, but was overlapped by the outer portion of the cyst. Inward from the coloboma, especially in the upper cup, the tis-

sue of the iris appeared rarefied, and the black pigment of the uveal layer became visible through the cyst.

My opinion was that this cystic tumor had its origin in that portion of the tissue of the iris which was involved in, and attached to, the corneo-scleral cicatrix. It had first grown within that portion of the iris which lay inward from the coloboma. Its anterior wall soon projected over the anterior surface of the iris, extended, in its upper part, over the pupil and the outer portion of the iris, and became so much filled that it touched the posterior surface of the cornea, and crowded the iris and lens backward. The tumor was evidently still progressive.

All the cysts of the iris which have been recorded up to this day (about 22 in number) *were, when left untouched, destructive to the eye, and several of them even caused sympathetic inflammation of the other eye.* I therefore was convinced that nothing but an early operation could save the eye of the patient, and my opinion was confirmed by further examination.

The eye was painful to the touch, exhibited a manifest increase of tension, which remained unvariable during the four following days. $S = \frac{1}{25}$. $M = \frac{1}{14}$. The other eye was emmotropic; the O S revealed nothing remarkable in the fundus of either eye, especially no staphyloma posticum of the left. The myopia of this eye was surprising, in consideration of the fact that iris and lens were considerably pushed backward, which condition of itself evidently would have rendered the eye hyperopic.

This, however, did not take place, but just the contrary, which may be explained in the following way. The cyst pressed forcibly on the lateral portions—except the lower one—of the lens, and thereby caused a bulging of that portion of the anterior lens surface which was not covered or pressed upon by the tumor. A circumscribed augmented convexity of the anterior capsule must have been produced to such a degree as not only to counterbalance the optic effect of the retrocession of the lens, but even to cause considerable myopia.

The nature of the disease, and the painfulness, increased tension, and impaired sight of the eye, forced the unswerving conviction upon me that the eye was sure to be destroyed unless the growth of the cyst were checked. To expect this from anything else but an operation, could not be thought of. Puncture of the cyst would surely have been followed by a recurrence. The removal of the whole cyst seemed impossible without rendering the operation too perilous by the extent of the wound. I therefore concluded to take away as much of the tumor as I could without exposing the eye to a greater danger than is borne safely in ordinary operations. If a recurrence should follow, I imagined, then the incipient state of the refilling cyst would show a tumor smaller and easier to remove totally by a subsequent operation. I operated in the following way. With a broad lance-shaped knife I made an incision at the inner side of the corneo-sclerotic juncture, near the corneal margin, but within the sclerotic border. The inner portion of the

cyst, of course, was penetrated and emptied by the knife. Introducing a pair of delicate iris-forceps, and trying to seize that piece of the cyst which lay over the pupil and the outer part of the iris, I found an insurmountable obstacle in the vertical septum (*s*, Fig. 5). I therefore seized the latter by widely opening the branches of the forceps, and, after closing them, I had the pleasure of seeing the whole inner part of the iris come out. Cutting it off close to the wound produced a wide coloboma, in which none of the inner part of the iris remained behind. The condition of the eye, after the operation, is represented in Fig. 6. The uncovered part

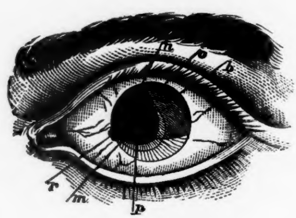


Fig. 6.

of the pupil, which before the operation had been small and triangular (*p*, Fig. 5), had enlarged to a broad stripe, reaching the inner margin of the cornea (*p*, Fig. 6). The broken wall of the outer cyst still covered the outer part of the iris (b), and its lower border (*m*, Fig. 6) stretched across the upper pupillary space nearly as far as the inner corneal margin. In seizing the septum I had caught hold of the overlapping portion of the outer

cyst, and dragged it necessarily towards the wound, in which, however, it was not involved.

A moderate degree of irritation followed the operation. Tolerably well marked circumcorneal injection, and some swelling of the border of the upper lid on the following day, were symptoms not altogether pleasant, but they were counterbalanced by the total absence of pain, and normal appearance of the lower part of the iris. I abstained, therefore, from any severer treatment. The eye recovered very rapidly. Ten days after the operation a slight protrusion of iris in the corner of the scar of the iridectomy wound was noticeable, which increased somewhat during the following days, representing a condition which we not infrequently see after large excisions of the iris in operations for glaucoma or extraction of cataract. The sight of the eye was greatly improved, the tension of the globe lessened, but in the upper part of the pupil there seemed to be a renewed and circumscribed swelling (*n*, Fig. 6) of the cyst, the walls of which, up to that time, had lain shrivelled up and flat upon the lens and outer part of the pupil, the anterior chamber having been, soon after the operation, fairly re-established. Since this swelling threatened to cause a refilling of the cyst, and in any case darkened a considerable part of the pupillary field, I decided to remove it, if possible, together with as much of the adjoining part of the iris as I could, by another outward and upward iridectomy. After having made a broad incision at the upper and outer corneal

margin, I introduced a blunt (Tyrell's) hook in front of the iris and remaining part of the cyst, as far as to bring the point of the instrument behind the inner edge of the cyst. I grasped with the hook the peripheral portion of the cyst near the point *m*, and proceeded to draw it out in the direction towards *b* (Fig. 6), together with the iris beneath it. At first the cyst followed nicely, separating itself from the capsule of the lens, but its attachment to the upper part of the primary coloboma and to the scar did not give way, so that the tissue of the cyst was ruptured, and only the middle portion of it extracted and cut off with the iris. By means of forceps and a sharp iris hook I attempted, with great care not to wound the lens-capsule, further to remove the upper and lower remnants of the cyst, but succeeded only partially. After having done this, I excised the small prolapse of iris in the corner of the first iridectomy wound (*r*, Fig 6). The operation was followed by no pain, but the globe became red, and the upper lid swelled. No remedy was administered except atropine. The eye recovered rapidly from the operation, sight improved, and the small remnants of the cyst shrivelled up, resembling patches of connective tissue. A week after the operation the very lively young patient, having been imprudent in walking, and eating more ice-cream than was good for her, felt feverish and sick, and vomited several times. She had some pain in her eye, and an abundant running of tears. I did not see her till the following day, and found the eye red again, the anterior chamber quite empty, and the

iris greenish discolored. I ordered six leeches to be put in the temple, and kept her in bed for two days, having atropine dropped into her eye every hour. The iritis at once subsided, the anterior chamber slowly refilled, the visual field, which had become densely clouded, cleared up again, and at the end of five days the consequences of this inflammatory attack had disappeared. A week later, that is, three weeks after the second, and five after the first operation, the patient returned home, her eye being in the following condition. It was still very sensitive to brilliant light. Vision $\frac{1}{10}$, having been $\frac{1}{25}$ before the first operation. The *myopia had disappeared.* She could read Sn. CC at 20′ distance, and said that concave glasses made the letters no clearer, whilst convex glasses made them blurred. F was normal, and T no longer increased. Subconjunctival vessels were still somewhat injected. The cicatrix from the first iridectomy showed again a small prolapsus iridis in the

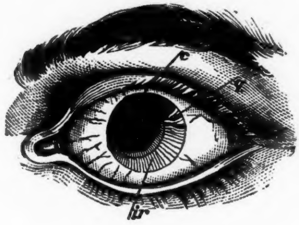


FIG. 7.

lower corner, and there seemed to exist some tendency to cystoid protrusion of the cicatrix. The second iridec-

tomy wound was firmly united; the outer surface of the cornea clear and sensitive; its inner surface, however, showed in its upper inner part (*c*, Fig. 7) some dark grayish spots, like connective tissue, probably the remainders of the shrivelled cyst having become attached to the cornea during the evacuation of the anterior chamber. The lower and outer portion of the iris (*ir*, Fig. 7) appeared quite normal, only the corner (*g*, Fig. 7) bordering outwardly on the coloboma was still covered by a delicate grayish membrane, being the last remnant of the cyst wall. The lens was transparent throughout, but some opacities upon the capsule had remained behind. It seemed to be somewhat pushed forward, the anterior chamber having not yet regained its natural depth. The interior of the eye could be well illuminated, but I was unable to distinguish the details of the fundus on account of the irritability of the eye.

I should have been glad to remove the last remnant of the cyst, together with the small part of iris beneath it, but at the second operation it was not possible to excise it without giving the wound such an extent as to endanger the eye. To take it away now, three weeks after the second operation, did not seem advisable either, since the endurance of the eye for further operations, as well as the patience of the little sufferer, appeared to be exhausted. Apart from this, the refilling of the cyst could not be predicted with any degree of probability. If it should occur, which was no more than a mere possibility, less supported by the analogy of similar observa-

tions than apprehended by our sympathizing care for the amiable young patient, an ultimate operation in order to take away the small remains of the cyst would not have been so perilous as either of the preceding ones.

I examined the pieces of iris and cyst which had been removed by the first operation. The iris had preserved its natural structure, showing no degeneration, but some degree of atrophy. Upon it lay the delicate cyst-wall, composed of flat, very large, polygonal epithelial cells.

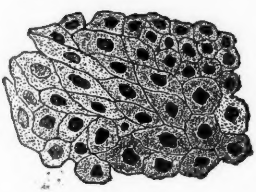


FIG. 8.

I could not make out a basement membrane between these cells and the iris, but a piece of the free wall of the cyst exhibited the parallel and winding lines characteristic of homogeneous membranes, for instance, the glassy membrane beneath the pigment epithelium of the choroid. Therefore it was evident that the *wall of the cyst consisted of a delicate homogeneous (glassy) membrane lined with pavement epithelium.* Its contents were entirely transparent and fluid, like water. They could not be gathered during the operation, although I tried to obtain them.

The origin of cystic tumors of the iris has been much discussed of late. There are three opinions on it:—

(1.) They are said to be the dilatation of pre-existing free spaces in the iris. (2.) They are regarded as new formations, a conclusive illustration of which is furnished by the highly interesting observation of *Von Graefe*, relative to a dermoid cyst in the iris containing atheromatous matter with short stiff hairs (Arch. f. Ophthalm., III., 2, p. 412, and ibidem, VII., 2, p. 39). (3.) They are supposed to develop by a process of sacculation in such a way that by adhesive inflammation, especially after penetrating wounds, the iris becomes attached to some part of the walls of the anterior chamber. If in such cases a free space between the attached parts is left, the secreted fluid will increase it to form a pouch, which by subsequent formation of a new wall will become a true cyst. This opinion, strongly advocated by *L. Wecker*, accounts best for the origin of the cyst in the case just described.

The unfavorable side of the *prognosis* of the latter depends upon the possibility that the last piece of the cyst left behind may become the starting-point of a recurrence, and besides that, in the predisposition for glaucoma in eyes with anterior synechiæ. A tendency to serous effusions is manifested in this eye by the cystoid cicatrix at the place of the primary injury, and, perhaps, by the small portion of iris involved in the lower angle of the first iridectomy wound. The large coloboma, however, and the youth of the patient, will, I suppose, counterbalance this tendency. As to the possibility of a recurrence, I think that what we know

on this subject does not speak for its probability, since iris cysts did not reappear even after simple paracentesis, or after removal of their anterior (free) wall, whilst in the case under consideration only a very small part of the cyst wall, and the iris beneath it, is left behind, but the bulk of the tumor, and all the iris with which it was connected, are taken away.

Since I wrote the foregoing, which was at the time of the patient's discharge, I have had repeated information with regard to her health. The eye has completely recovered, there is no irritability of either eye, and no cystoid protrusion of the wound has developed. The lower part of the iris is somewhat drawn upward, encroaching upon the clearest portion of the pupil; vision, however, so far restored that ordinary print can be read with the injured eye. This was the condition of the patient according to the latest information, which I received a few days ago,—seven months after the operation.

CASE OF EXTIRPATION OF A CANCROID GROWTH OF THE INNER CANTHUS AND UPPER EYELID. BLEPHAROPLASTY BY SLIDING FLAPS.

BY H. KNAPP.

THE unsatisfactory results obtained in many cases of blepharoplasty by transplanted flaps of skin, due to subsequent contraction and thickening, with very unpleasant consequences, induced me, during the last few years, to cultivate more the method of the *sliding of flaps.* My experience in this direction has been so far very encouraging. Two extremely satisfactory cases I have published a short time ago, the one in the "Arch. f. Ophthalm.," XIII., p. 180, etc., and the other in the first number of the Archives of Ophthalm. and Otology, p. 139.

The following case is analogical to the two preceding ones, but offers peculiarities with regard to the mode of operation which may prove useful in the treatment of similar difficulties:—

Sea-Captain M., of Scotland, 45 years of age, healthy

and robust, observed about two years previously a small, hard, circumscribed elevation in the skin of the upper eyelid and the inner canthus. It gradually increased, was surrounded by other nodules, and constituted, at the time when he came to me, August 23d, 1869, a nodular thickening of the skin upon and above the inner canthus (see Fig. A), twelve millimetres in breadth and thirty

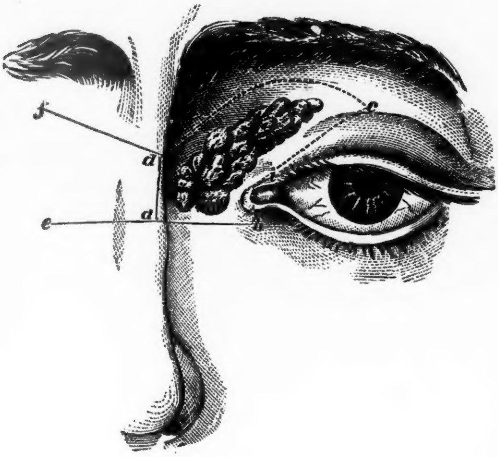


FIG. A.

in length. The tumor was felt by the exploring finger as a dense mass receding into the orbit, but without firm attachments to the bone. Since it presented all the qualities of a cancerous growth, the patient agreed at once to its removal by an operation, which advice had been already given to him by some other physicians.

I circumcised it by a curved and angular line fully

within the healthy skin (*a b c d*), and dissected it carefully and slowly through the healthy tissue of the orbit, guiding my steps always by the exploring forefinger of my left hand. The ligamentum canthi, being quite unaffected, could be spared, but above it I found the tumor penetrating into the orbit about half an inch, so that after its removal a considerable hole was visible. The inner portion of the cartilage of the upper lid had been taken away. The defect of skin which reached from below the inner canthus and the root of the nose obliquely upward and outward as far as the eyebrow, and a little beyond the middle of the upper lid, was covered by sliding flaps in the following manner:—A straight cut, *a e*, was made through the skin horizontally over the back of the nose, in prolongation of the lower border of the wound *a b*. Another straight cut, *d f*, went through the skin from the inner upper orbital angle towards the brow of the other eye. The flap comprised between these two lines was dissected from the original wound towards its basis, which lay on the other side of the nose. Next I dissected the inner portion of the lower lid, *b*, from the subcutaneous tissue of the conjunctiva, and separated, to the extent of some lines, the skin of the upper lid along the wound *b c* from the orbicularis muscle and cartilage. I then united the lower end, *a*, of the nasal flap with the inner end, *b*, of the lower lid, which caused considerable stretching of the latter and the flap. The lower border of the flap was united by silk sutures with the adjacent skin without marked puckering of the latter. Then the

inner part, *i*, of the upper lid was fastened to the opposite border of the nasal flap. The wound now looked as represented in Fig. B. A simple stitching together of the

Fig. B.

upper lid and the nasal flap could not be thought of, because it would have occasioned a very disfiguring ectropion. To make a cut through the upper lid, parallel to the margin of the lid, and shifting the latter towards the nose as far as to reach the flap, was quite impracticable, because the tendon of the levator muscle must be preserved lest incurable ptosis be the consequence. For this reason the method which I have very successfully applied to the lower lid, is not applicable to the upper. To obviate both these difficulties, ectropion and ptosis, I made a vertical cut, *n m* (Fig. B), from the

inner upper angle of the wound, about three-quarters of an inch in length. Now I dissected off the skin situate above the wound, and fitted the angle *m n c* into the angular defect *d i c* (Fig. B), uniting the edge *n c* with *i c*, and the lower part of *n m* with the upper part of the vertical margin of the nasal flap. The remaining small triangular defect, *d n m* (Fig. B), was covered by loosening from its base the triangular flap of skin *m n f*, lying above the quadrangular nasal flap, and by uniting its edges with the opposite edges of the remaining triangular defect.

FIG. C.

In this manner the whole wound was closed, and the region of the operation had the appearance which is represented by Fig. C. Both eyelids were stretched

towards the nose, a slight degree of eversion of the inner margin of the upper lid existed, and the transplanted portions of skin, now situate over the inner canthus, stretched over a hollow space, the former seat of the orbital portion of the tumor. I considered this hollow space a favorable condition, presupposing that the cicatricial tissue which was to fill it up would draw the skin bridging loosely over it, backward into the orbit. This expectation was fully realized. There was but trifling suppuration in this space. The whole wound healed by first intention, and the slight degree of eversion of the inner portion of the upper lid entirely disappeared, in consequence of the retraction of the cicatrized tissue near the inner canthus. The upper lid was perfectly movable, and the palpebral fissure closed easily at will and during sleep. Epiphora was the only thing the patient had to complain of. The interference with the canaliculi and the removal of the m. compressor sacci lacrymalis were the unavoidable cause of this not very material annoyance.

About a fortnight after the operation the patient was presented to the Medical Society of the County of New York, when he was examined by the scrutinizing eyes of the most experienced surgeons of the metropolis, who pronounced the result of this blepharoplasty as the most satisfactory that could have been obtained. A week afterwards the patient went on board ship again, and, four months later, he wrote to me that his eye continued

in excellent condition, showing no disfigurement or annoyance, except simple lachrymation.

On *microscopic examination* I found in the specimen the ordinary structure of epithelioma. Its peripheral portions were very vascular, and consisted mainly of smaller epithelial cells densely interspersed with lymph corpuscles, which penetrated also in large quantities into the neighboring connective tissue of the orbit. The epithelial cells of the growth were accumulated by homogeneous juxtaposition, presenting but rarely the well-known cone-like figures. In some places the large epithelial cells were very distinctly *serrated* (Stachelzellen), and, with an immersion system, the small projecting bristles or hairs could be clearly seen not only at the border of the cells, but on their surface.

From the abundance of blood-vessels, and the infiltration of the tissue around them with lymphoid bodies, the following inference concerning the mode of development of the growth may be made: the lymphoid bodies were white blood corpuscles having transuded through the walls of the capillary blood-vessels; they, being movable, infiltrated the surrounding connective tissue, and developed in the mucous layer into epithelial cells.

ON THE MEASUREMENT OF THE PROMINENCE OF THE EYE.

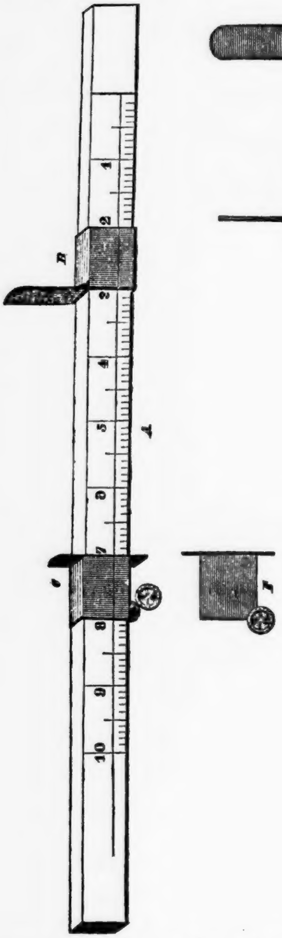
By P. KEYSER, M.D.,

Surgeon to the Philadelphia Eye and Ear Infirmary.

Some years ago, being desirous of measuring the prominence of the eyes in a case of Graves' disease, and knowing that the edge of the outer wall of the orbital foramen is never covered with anything more than thin integument at all times, by lean or fat persons, I thought this quite a good point to measure from, and had a little instrument made for that purpose, which has been very serviceable to me ever since.

It is made of ivory (or of metal), 15 centimetres long, 6 mm. wide, and 3 mm. thick—Fig. 9, "A." It is ruled with the centimetre and millimetre scales. On one end is a silver slide, with a projecting part for fixation against the orbital edge of the malar bone, see "B" and "E;" this slide works on a stiff spring, set in to hold it firm in place, but still allows it to be moved when required. On the other end is another slide, working on a very light spring and easily movable, having a ratchet

and thumb-screw to regulate its movements, and has projecting from it two uprights of thin steel. See "C," "D," and "F."



I move the slide *B* on the rule, to give me a good long, firm rest against the side of the face between the ear and eye, placing the projecting part of the slide *B* well against the orbital edge of the bone, and hold it firmly with one hand, while with the other the slide *C* is brought up and regulated so that the little upright stands exactly on a line with the outer surface of the cornea, the patient being directed to look steady at a fixed point directly in front. The distance between the two slides gives the prominence of the ball from the skin, and from the bone add 2 mm. At the same time the exact measure of the cornea can be taken by marking the sclero-corneal line.

The slide *C* having an upright on either end makes it suitable for either eye.

After measuring many hundreds of eyes with this Exophthalmometer, I find the prominence to be in a healthy normal state from 9 to 18 mm. In many cases of myopia I have found no material change, while in others great extension was perceived.

In one case of a myopia of $\frac{1}{3}$, the R. E. showed a prominence of 19 mm. and the L. 20 mm.

In a few cases of Morbus Basedowi (Graves' D.) that I have seen, the prominence was from 20 to 22 mm., and in one very marked case of exophthalmus, which came on gradually in about three years, without any sickness or symptoms of Graves's disease, the prominence reached 24 mm.

I found the average prominence in health, at and above maturity, to be 14 mm.

It was seldom that there was any material difference in the eyes; the greatest amount I found was 2 mm. In very many persons, if not a great majority of the people, the two sides of the face are not equal, one being more prominent than the other, so that one eye appears more projecting; but as we desire to have the prominence of the ball beyond the orbital foramen, it matters not if the outer edges are not exactly equal and on the same line; this is governed by the whole contour of the face.

Since reading Dr. *H. Kohn's* (of Breslau) able article in the Klinische Monatsblätter, V. Jahrg., p. 339, with whose exophthalmometer I am much pleased, I have examined

and measured a great many skulls, and find that the supra-orbital arch is often as irregular as the outer malar edge; and the integument is so irregular in one and the same person, that I really think the outer edge from which I measure is about as correct as any point found yet. In no one skull did I find the mastoid processes on the same line or of the same shape, so that from them I could not get even and exact centre lines for points to measure from. But on measuring from the tubercles on the temporal bones, or a line drawn through the centre of the glenoid fossa on either side, I found the measurement of the two sides pretty nearly if not exactly alike.

A NEW FORM OF WIRE SNARE FOR THE REMOVAL OF AURAL POLYPI, MODIFIED FROM THAT OF WILDE.

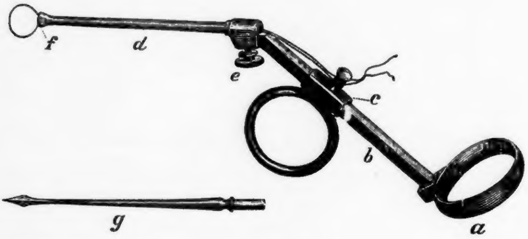
By C. J. BLAKE, M.D., Boston, U.S.A.

Among the instruments employed for the removal of aural polypi, the wire snare designed and introduced by Sir Wm. Wilde is the one in most general use. Modifications made by different operators are numerous, but in all the general form has remained the same.

While operating with a Wilde's snare upon a polyp deeply seated upon the anterior wall of the meatus, I conceived the idea of an instrument which should obviate the necessity of turning the hand, and with it the whole instrument, to enable the wire loop to be slipped over a growth springing from the sides of the meatus or the cavity of the tympanum, and ordered one made for me by Leiter of Vienna.

This I operated with several times, and modified successively until it reached its present form, constituting in point of fact two instruments, a snare and a myringotome. (See figure.)

The tube, slide, and thumb-ring are made of German silver (Pakfong), the remainder of the instrument of steel.



The thumb-ring (a) screws on to the lower end of the handle (b), and can be easily removed, or, by slightly unscrewing it, can be turned to the right or left to suit the convenience of the operator. On the handle (b) runs the slide (c), furnished below with a ring for the middle or index-finger, and above with a pin for the attachment of the ends of the wire.

The upper end of the handle enlarges to form a band into which the tube (d) is inserted, and fixed in position by the small set-screw (e).

As is shown in the engraving, the tube widens at its extremity to form a flattened head (f), having two small openings in its face for the passage of the wire. These openings unite below the head to form a common canal.

By unscrewing the thumb-ring (a), allowing the slide (c) to slip off, and substituting for the tube (d) the lance-headed needle (g), we have an instrument which

has the advantage over the one in general use, that the broad lance-head may be given any desired direction, being kept in place by the set-screw (e). Other instruments may be substituted for the needle.

When the growth to be extracted arises from any part of the meatus other than the superior or inferior wall, that is to say, directly in the median line, it is necessary, with Wilde's snare, either to turn the instrument sideways, which is at least inconvenient, or to twist the wire upon itself, in order to bring the flat of the loop in contact with the base from which the polyp springs.

In the latter case, when traction is made, the wire tends to return to its original position and the growth is apt to be obliquely excised, in place of being cut off close to its base.

In substituting for the fixed bar of Wilde's snare a movable tube, this difficulty is obviated.

The broad head, and with it the wire loop, can be given any desired direction, and the instrument introduced without changing the position of the hand.

In operating I have found a ring upon the slide more convenient than two arms, and by fastening the ends of the wire to a pin above the slide they are out of the way of the operator.

When greater steadiness is desired, the index finger may be rested upon the small set-screw and traction made with the middle finger.

In a narrow meatus it is also an advantage to have

the wires enclosed within a tube, in place of running upon the outside of a bar.

In setting the instrument the wire should be passed through the two holes in the head and down the tube, the two ends being twisted around the pin in opposite directions; the head of the tube is made to flare outwards gradually, and the liability of the wire to break thereby diminished.

Of the different kinds employed, I have found the Lyons wire suggested by Prof. Moos to best answer the purpose; it is soft, and yet sufficiently stiff to bear considerable pressure.

The size No. 12 (silvered), used for sewing leather, is perhaps the most convenient, and has an advantage over the annealed iron wire in being smoother and less likely to break with continued use.

In employing the needle for the purpose of perforating the membrana tympani, the plane of the lance-head being turned in the direction in which the incision is to be made, and the needle then screwed tightly in position, a direct puncture may be made without moving the hand to right or left, and greater steadiness in operating thereby secured.

REPORT OF A CASE OF DETACHMENT OF THE CHOROID FROM THE SCLEROTIC AFTER AN OPERATION FOR CATARACT, WITH PARTIAL LOSS OF VITREOUS BODY.

By GEO. REULING, M.D.,

Surgeon to the Maryland Eye Infirmary, Baltimore.

The fact of the occasional separation of the choroid membrane from the sclerotic has been demonstrated by the ophthalmoscope and by dissection.

V. Gräfe had already, in 1854, diagnosed, by the aid of the ophthalmoscope, a similar case, and has described (Archiv für Ophth., Bd. IV., Abth. 2) two other cases which he observed in 1855 and 1857. These three cases had, as a common feature, separation of the retina superadded to and consequent upon the choroid displacement, with total atrophy of the ball. His opinion as to the physical cause of the lesion could be only approximatively given in the absence of opportunity for dissections. The result to which he however arrived was, that the lesion had its origin in effusion, either serous or sanguineous. The fact of the existence in one case of effused blood at the dependent portion of the periphery of the prominent de-

tached choroid seemed, however, to Gräfe to favor the view of an apoplectic origin, while in others the subsequent separation of the retina by serosity, and the consequent atrophy of the globe, suggested that the whole process might be attributed to that serous effusion which had been so prominent in the later phenomena. *Liebreich* has also (Traité pratique des maladies de l'œuil par Mackenzie : Section : Décollement de la Rétine et de la Choroïde d'avec la Sclérotique), as well as in Archiv für Ophth., Bd. V., Abth. 2, described similar cases, and enriched our knowledge by many interesting observations, and also by a very valuable drawing of the ophthalmoscopic appearances in a case of detachment of the choroid (Tab. vii., fig. 4 of his Atlas). The rarity of this affection readily accounts for the small number of pathologico-anatomical researches. We find, however, one recorded by *Ammon* (Zeitschrift für Ophthalmologie, Bd. II., p. 24) and three by *Stellwag* (Ophth., 1856, Bd. II., p. 98, par. 142, Anmerk. 109). The greatest interest attaches to cases very fully reported with valuable details by *Iwanoff* in "*Archiv für Ophth.*," Bd. XI., Abth. 1, and also by Prof. *Knapp* in his work upon *Intraocular Tumors.*

The latter author describes, page 194 (261 Am. edit.), a very interesting, and at the same time instructive case, in which, about seven weeks after the extraction of the opaque lens, the whole of the corpus ciliare and the attached choroid were found separated from the sclerotic in the enucleated eye. Prior to enucleation, *Knapp* had already, by the aid of the ophthalmoscope, recognized a

prominence, of hemispherical shape, which he took for an encysted coagulum of blood rather than for melanotic sarcoma, to which it bore a great resemblance. In this case (vide Fig. 69, op. citat.) the sclerotic was much thinner than normal in the ciliary region, and considerably thickened at the equator, so that *Knapp* attributed the serous separation of the parts to a plastic sclerotitis, due to the forcible extraction of the lens, which caused at once the thickening of the sclerotic, and the effusion of serum between this membrane and the corpus ciliare, and thus gave rise to bellying of the choroid. In an article by my friend Dr. *de Gouvea*, which appeared in *Gräfe's Archiv* (Bd. XV., Abth. 1.), are related two cases of separation of the choroid, both of which (Cases II. and III.) were attributed to a considerable puffiness (Auflockerung) of the lamina fusca, due to structureless exudation.

Choroid detachments due to hemorrhage from the posterior surface of the retina, after operation for cataract, together with the anatomical appearances, have been described by Mr. *Hulke*, and after him by *Bowman*, *White Cooper*, *Lawson*, and others. Such hemorrhage occurs only in eyes previously diseased, and my own experience offers a very striking case in which, immediately after an otherwise normal operation for the extraction of both lenses of an old lady, the subject of arterial atheroma, a severe attack of pain was accompanied by the protrusion in both eyes of the vitreous body through the wound in the cornea, followed by

swollen and cyst-like retina and choroid. At the same time there was a very severe hemorrhage from the choroidal vessels, which could only be restrained by styptics and compressing bandages. Of course both eyes were totally destroyed by the ensuing suppuration.

I shall now relate the case to which the title of this communication refers.

In the spring of 1867, a peasant woman, aged 45, the subject of double uncomplicated cataract, was admitted for operation into the Eye Hospital at Wiesbaden.

State on Admission.—Right Eye: Only motions of the hand perceptible, with perfectly responsive pupil, and undiminished field of vision.

Left Eye: Fingers at eight feet. The patient was an anæmic and easily excitable subject, belonging to the laboring class, and was operated upon while under chloroform by Dr. Pagenstecher. Lower flap operation and large iridectomy, with attempt to slip out the lens by rocking motion (Schlittenmanöver), which being unsuccessful, Pagenstecher introduced his own scoop between the posterior surface of the lens and the fossa hyaloidea, and by the aid of slight pressure upwards, and careful traction, succeeded in separating the lens from its connection with the zonula, and accomplished its extraction with the unbroken capsule. A small quantity of vitreous body, to the extent of about 15 drops, and of normal appearance, escaped through the wound, immediately following the lens. The cornea collapsed to a moderate degree, and there was a slight trace of hemorrhage in the anterior chamber. The corpus vitreum had, with the exception of a small particle caught in the wound, entirely regained its normal position.

Solution of atropia was now instilled and the eyes bandaged.

1st day. The first 24 hours were passed favorably. The patient had vomited somewhat on two occasions on awakening from the narcosis. This, however, did not prevent the prompt and entire closure of the wound. Cornea smooth and convex, aqueous humor almost perfectly

clear, only a slight streak of blood on the face of the iris. The patient counts fingers at 4 feet.

2d day. Patient very comfortable, and all well.

3d day. Patient complains of great feeling of fatigue, depression, and chilliness. No complaint as to the eye. Fingers counted at 6 feet. Temperature and pulse rate markedly increased towards evening, and slight delirium appeared. The remission in the morning was accompanied by a diminution of temperature amounting to 1°. Two days subsequently a notable increase in the area of splenic dulness could be perceived, profuse painless diarrhœa appeared, and in the night of the 6th day the delirium became furious, so that the patient tore off the bandages, and thus gave rise to a gaping of the wound and hemorrhage into the anterior chamber. The bandages were immediately replaced, and the patient, uncontrollable in her delirium, was sent to the city general hospital, where, after three weeks, she gradually sank into excessive weakness and death. The post-mortem examination yielded comparatively slight changes in the mucous membrane of the ileum, consisting principally of ulcers in the process of healing, and a corrugated appearance of the capsule of the spleen, due to the contraction of the previously swollen organ. The brain and optic tracts showed no perceptible lesion. The eye was now enucleated, and immersed for the space of two weeks in Müller's fluid. It was then carefully divided in the horizontal diameter into two equal sections. This yielded the interesting discovery of the total separation of the choroid from the sclerotic, between which two membranes a jelly-like exudation to the extent of 0.5‴ in thickness was spread. It had been unquestionably in a fluid state prior to the hardening in Müller's fluid. The separation extended from the circumference of the optic disc to the ciliary ligament, and was complete, so that the exudation removed the choroid from the sclerotic over its whole extent to an almost equal degree. The arteriæ ciliares posticæ breves, and the ciliary muscle near the canal of Schlemm, constituted the only connection between sclerotic and choroid. No detachment of the retina was anywhere perceptible; choroid and retina were in perfect apposition and showed no trace of wrinkle. The corpus vi-

treum was perfectly normal, and a microscopical examination of the structure discovered no change. The gelatinous exudation was perfectly clear, with the exception of a few points of slight opacity. Under the microscope there was no trace of structure visible, only here and there were a few granular fibrils and particles of coagulated fibrin, to which were attached a few pigment grains and cells of the lamina fusca.

This case suggests diverse reflections. The cause of the choroid detachment is simply to be sought for in the vacuum produced by the removal of the lens and the escape of part of the vitreous body. It is not probable that the accident happened at the time when the patient violently removed the bandages, and thus opened the wound and occasioned the hemorrhage; for on this occasion there was no loss of vitreous body. The loss of aqueous humor could have been but light, since the anterior chamber was perfect as I replaced the bandages. It is thus rendered exceedingly probable that the total detachment of the choroid does not involve total loss of sight so long as a connection between this membrane and the retina is unbroken, or, at least, that it does not lead to this result in the earlier stages of the lesion—for it will be remembered that three days after the operation the patient could count fingers at six feet distance. The art. cil. post. brev., in the circumference of the optic disc, were, as before mentioned, not ruptured (the exudation between sclerotic and choroid was not blood-stained), and therefore there was an uninterrupted blood supply from this source as well as from the branches of the art. cil. long. et ant., which course

backwards from the ciliary body, and, anastomosing with the terminal branches of the art. cil. breves, form a delicate network which extends to the ora serrata, and is closely continuous in the neighborhood of the entrance of the optic nerve with the capillary vessels of this nerve (*Leber*). There is no doubt that a longer duration of the affection under consideration would lead, through disturbed nutrition and gradual separation of the retina, to total blindness; and it is to be regretted that after the manifestation of phenomena of excitement in our patient, no test of vision could be had, and that the bleeding into the anterior chamber prevented all attempts at ophthalmoscopic examination.

THE USE OF ACETIC ACID IN AFFECTIONS OF THE CONJUNCTIVA AND CORNEA.

By B. A. POPE.

The acid used in the following experiments was uniformly of the specific gravity of 1,041 (No. 8). My experience in its use in other strengths is not sufficiently extended for the expression of an opinion upon its value.

At first I applied the acid by means of a soft piece of wood, sharpened to a very fine point; but subsequently substituted the smallest size camel's-hair brush. In making the application, great care should be taken that the brush should not hold too much of the acid, and it is well also to remove any moisture from the surface to which it is to be applied.

Its action in the strength indicated is that of a mild escharotic, when applied to the cornea or the conjunctiva, causing but moderate reaction and very transitory pain. As compared with the nitrate of silver, used in strong solutions or in the solid state, the pain and irritation produced are very slight. This is also true as regards its

action when compared with that of the sulphate of copper. The epithelial slough falls away rapidly, and leaves a clean surface, which, as a rule, heals promptly.

In the following cases I found this acid to be a valuable agent :—

1. In a case of *warty degeneration* of the palpebral conjunctiva.

The patient, a boy of twelve years old, had been treated for two years before coming under my care. The tarsal conjunctiva of the upper eyelids was almost entirely occupied by these growths, only the inner and outer portions of the lids having been free from them. They were packed closely together, and were flattened upon their surfaces where they came in contact with the eyeballs. The largest of the tumors was about one-sixth of an inch in length, firm in structure, and sprang from the middle of the lids. Here and there, towards the inner and outer canthi, there were small flat growths varying from the size of a small pin's head to a line in diameter. There was only moderate conjunctival irritation, and but little secretion of mucus. The corneæ were perfectly healthy, but the use of the eyes was unpleasant.

The growths were excised as closely as possible to the surface of the lids. They, however, so completely occupied the tarsal surfaces of the lids, that it was impossible to make the excision so as to leave a smooth surface. The tendency to reproduction was very great, and it was found necessary to cauterize the diseased surfaces with

the solid nitrate of silver every day for at least two months. At the end of that time the right lid was well. The treatment for the left lid was terminated at the end of five months. During the latter part of the treatment the sulphate of copper was sometimes used. After the first two months the nitrate of silver was generally applied every second or third day.

After three months the patient again returned for treatment, the left lid being almost in the same condition as before I had commenced treatment; and the disease also commencing to show itself again on the right lid. I now determined to try the effects of acetic acid, without previously excising the growths.

The applications were made once a day for about six weeks. In a week from the commencement of this treatment the right lid was well. In from six weeks to two months the left lid was also well. During the last week of the treatment the solid nitrate of silver was used two or three times with benefit.

The pain was very moderate, and the irritation following the applications was very slight. As compared with the applications of the nitrate of silver, or even of the sulphate of copper, the difference in these respects was very great. The patient consequently expressed himself as being much in favor of the change in treatment.

In the latter part of the treatment the whole thickness of the epithelial layer would slough in places, and this would be followed by a little hemorrhage and some increase in the amount of pain.

It is now about five months since the cure was effected, and there is no tendency at present on the part of the disease to return.

There are in such cases serious objections to excising the growths, and following this by the use of strong caustics. This treatment almost certainly produces an uneven surface, which causes chronic irritation, by the unequal pressure of the surface of the eyelids upon the balls. If strong caustics be used for a long time upon the growths, the violent irritation produced is liable to be prejudicial to the healthy conjunctiva and cornea. Acetic acid seems to answer the indications best, since its action appears to be in a great degree confined to the immediate points to which it is applied. In case the growths are isolated and large, and attached by a small base, excision is of course indicated. In this case the deeper tissues of the lid were beginning to be involved in the morbid process, and the tumors were closely packed together.

Each application of the acid caused the destruction of the epithelial layer, in which the morbid process seemed to originate. As a rule it did not slough at once, but upon the return of the patient in 24 hours the epithelium had been reproduced. The acid was always applied very freely.

2. In the greatly relaxed condition of the conjunctiva of the cul-de-sacs with hypertrophy of the epithelial layer which occasionally follows upon chronic conjunctival disease. I have frequently found this condition of

the conjunctivæ in cases of chronic catarrhal affections occurring in orphan asylums, and in some instances they were very rebellious to the usual treatment. This condition renders the patient constantly liable to relapses. One case of this kind, in which a constant irritation was kept up by the condition of the conjunctiva of the upper conjunctival cul-de-sacs, was cured completely by two applications, after having resisted the usual treatment for weeks without decided progress towards a cure. In this case, upon everting the upper lids, a large flabby mass would protrude which had a macerated appearance.

3. I have found benefit in its *occasional* use in some cases of trachoma in the stage of development, where the neoplastic growths were *very superficial*, and where the usual treatment seemed for the moment to favor the progress of the disease. Its application should be confined to the granulations, the surrounding conjunctiva being spared.

4. In a case of inflamed pinguecula, where excision was declined by the patient.

5. In the hypertrophied condition of the lachrymal caruncle and semilunar fold in cases of pterygium. It is probably best to use it before operating the morbid growth, since the cure is favored by having the tumors free from irritation before operation.

6. In two cases of *calcareous degeneration* of the *epithelial* layer of the *cornea.*

In each of these cases both eyes were affected, and in both the disease was more advanced in one eye than in

the other. The treatment was completed in only one of the cases. In this case the result was excellent in one of the eyes, and very unsatisfactory in the other. The eye which did well was by far the worst, the patient not being able before treatment to read the large letters of signs upon the streets, and the eye having become affected with strabismus externus. The eye which was a failure in respect to the operation did quite well after two or three operations in which the acid was used, and improved decidedly in the sight; but the last operation was followed by considerable irritation of the cornea and acute inflammation of the lachrymal sac. This last operation was performed with instruments, and without the use of the acid; so that the failure can in no way be connected with its use. In the cases reported by Bowman and Dixon the disease had advanced so far that the calcareous mass could be removed in a continuous solid plate. In the cases treated by myself the disease was in a comparatively early stage of development, and might easily have been mistaken for opacities resulting from a diffuse superficial keratitis. In fact, both cases had been so considered previously to their having consulted me, and had been treated accordingly, without any effect upon the course of the disease. From two of the corneæ I obtained small, coarsely granular, calcareous plates; but the epithelial layers were mostly in a sclerosed condition, the cells still retaining their forms and proper relations when seen under the microscope.

The treatment was commenced by the application of the

acid at the circumference of the diseased parts. After an hour or two the sloughing mass was removed, and if the whole thickness of the diseased epithelium had not been destroyed, the application was renewed at once, with, however, greater care than in the first application. Before another application was made, time was allowed for the restoration of the epithelium and the subsidence of irritation. In some of the operations I first scraped away much of the epithelium, and then made a slight application of the acid to the remaining deep epithelial layers.

The restoration of the epithelium took place very rapidly, and with so nearly normal transparency that in the eye on which the treatment was successful, the patient could read No. 1 of Jaeger's test-print at 7″ or 8″, while before the operation, with this eye, which was much the worse of the two, the patient could not distinguish the letters of large street signs, and the eye had in consequence deviated outwards.

From the observation of the effects of treatment in these cases, I concluded that unless some other procedure than that with the knife, or by sloughing away the epithelial layer, be resorted to, the disease had best be allowed to run its course to a rather advanced stage before operative intervention.

7. In a case of dense opacity of the cornea, the margin of which reached the centre of the cornea. This case I treated from the eighth day of an attack of ophthalmia neonatorum, complicated almost from the first by a severe attack of diphtheritis conjunctivæ. I first saw

the case on the eleventh day after the birth of the child. There had been no treatment, and I found the cornea commencing to slough, and severe iritis already existing. The eye was saved with difficulty, and perforation of the cornea was prevented. A circular slough came away, about $1\frac{1}{4}$ line in diameter, and probably involving $\frac{1}{3}$ or perhaps a little more of the thickness of the cornea. The healing of the ulcer and the condensation of the cicatrix was slow, on account of the unfavorable external and internal conditions present. At intervals, for some months, the various treatments usual in such cases for diminishing corneal opacities were used, but with unsatisfactory results. After some months had elapsed without treatment, I commenced the use of acetic acid. Its application was confined to the dense opacity, and its immediate vicinity, where the opacity was very slight. At first the application was made once a day for three consecutive days, so that an ulcer resulted from the treatment. This was allowed to heal without interference. This treatment was repeated after the ulcer had healed and all irritation had ceased. The application of the acid was made subsequently about three times, but each time only two applications were made. The opacity still remains, but is decidedly diminished in density, and somewhat also in extent. The healing of the ulcer took place under the most favorable conditions, which will probably sufficiently explain the improvement. In support of this view I might cite the case of a child, about three years old, who had a tolerably dense central opacity of the

cornea, which sloughed away under the influence of a severe catarrhal inflammation of the conjunctiva. The inflammation produced iritis and considerable softening of the corneal tissue. After the cure of these inflammations the ulcer healed, with a remarkable improvement in the opacity. The first cicatrization had taken place while the conjunctiva was still inflamed, the disease having been left mostly to take its natural course.

ANÆSTHESIA OF THE CORNEA, AND CONCURRENT DIMINUTION OF THE ACTION OF ATROPIA ON THE IRIS, AS INFLUENCING KERATIC ULCERATION.

By I. S. HILDRETH, M.D.,

Clinical Lecturer on the Eye and Ear at the County Hospital, Chicago.

From a series of observations upon this subject, the following case, reported by Dr. B. C. Miller, House-Surgeon, is selected as one of the most important.

Catharine Olston, Swede, age fifty-two, was admitted to the medical department of the hospital, April 18th, 1868. She had been suffering, for three months, from chronic diarrhœa, caused by exposure and bad diet. Her limbs were wasted, the countenance was haggard, and the skin shrivelled. On the 25th she first complained of her eyes. Examination discovered, near the lower margin of each cornea, an external ulceration, occupying quite one-third of its thickness, laterally elongated, and about one-sixteenth of an inch in vertical breadth. The pupils, a little contracted, slightly responded to the influence of light and shade. The corneæ were almost

totally insensible to touch. The passage of the point of a small strip of paper, torn from the margin of a magazine, twisted hard until like a sharpened lead pencil, the apex then slightly moistened, being scarcely felt, even when rudely drawn across them.

In neither eye was there intraocular tension, posterior synechia, discoloration of the iris, or perikeratic injection; and the corneæ, except at points of ulceration, were quite clear. Slight catarrhal conjunctivitis was present. General condition very weak.

Two or three drops of atropia solution* were instilled within the lids of each eye three times during the next eighteen hours. No other local treatment. April 26th.—The pupil of the right eye was slightly dilated, and the cornea had become somewhat sensitive to touch. Its ulceration had not increased. The pupil of the left eye remained contracted, and the cornea as insensible as before. Its ulceration had enlarged. General condition still declining.

27th.—Atropia had been applied, since last record, to each eye, three times. The pupil of the right was further dilated; the cornea more sensitive, and its ulceration showed signs of improvement. On the left, the pupil was still contracted, corneal insensibility remained, and its ulceration was increasing. General status worse.

28th.—Atropia had been further instilled twice as before. Right pupil well dilated, and the cornea quite

* Ten grains to the ounce.

sensitive. Its ulceration diminishing. Left pupil remained contracted; the cornea insensible, and its ulceration was further enlarged. General state of patient continued to fail.

29th.—Atropia had been instilled once in right eye; twice in left.

In the first the pupil was largely dilated, the cornea quite sensitive to touch, and its ulceration had still further diminished.

In the other the pupil remained contracted, and the cornea full as insensible to touch as at time of first examination. Its ulceration had extended from the point of commencement, at the lower margin, nearly to the centre of the pupil, thereby involving about one-half of the cornea.

The patient died, from inanition, during the following night. Careful watch could at no time discover any constitutional effects of belladonna.

The general treatment consisted of stimulating and sedative remedies, with a small portion of opium, and an appropriate supporting diet.

The above brief presents a patient emaciated, feeble, and shrivelled by one of the most depressing diseases.

No synechia, change of color, perikeratic injection, intraocular tension, or other apparent evidence of disease of the internal membranes existed. The corneæ were anæsthetized, yet clear, except at points of ulceration; and the pupils, though their dilatability was quite defective, were still perceptibly influenced by light and

shade. No local treatment besides atropia at any time was used. The right eye being susceptible to its influence, the pupil gradually dilated, and a concurrent removal of corneal anæsthesia followed, with, first, arrest of ulceration, and, then, reparative efforts.

The other eye being insusceptible to the remedy, the pupil refused to dilate, corneal anæsthesia persisted, and the ulceration steadily enlarged.

Notwithstanding the ophthalmic affection, when first observed, was quite equal in each organ, and of a nature —corneal ulceration—but too easily attributable to the *general* defective nutrition, yet that cannot be assigned as the principal cause. For such a conclusion must be untenable when local medication influencing one eye is followed by arrest, and even some repair, of the keratic disturbance, while the same treatment, finding insusceptibility to its influence, in the other eye is followed by continuance of the destructive process. The cause, therefore, was some *local defect* of nervous action, which belladonna was competent to relieve on the one side, while it failed on the other.

CONTRIBUTIONS TO PHYSIOLOGICAL OPTICS.

By B. A. POPE, M.D.*

1. *The effect of pressure upon the eye in the experiments for observing the entoptic currents and luminous bands.*

While making experiments for observing the entoptic currents, I remarked that they would at times appear sooner and more distinctly when my eyes were strained by looking as far upwards as possible. Intermittent pressure upon the eye with the eyelids has the same effect. Also, at times, when my eyes were turned away from the *strong* light, and the eyelids were closed, moderate pressure on the eylids with the fingers would cause a reappearance of the currents. These facts caused me to study more closely the effect of pressure, exerted by means of the finger, during the experiments. When at times, upon commencing the experiments, the currents do not appear, they immediately do so when a certain

* This is the continuation of the article entitled "Entoptic Phenomena connected with the Circulation of the Blood," which appeared in Vol. 1, No. 1, of these Archives. This portion reached the editors too late for publication in the same No.

amount of pressure upon the ball is exerted with the finger. When my eyes have been fatigued by observing the currents, and these in consequence become obscure or entirely disappear, pressure upon the eyeball will cause them at once to appear more distinctly or to reappear. When I observe the currents and the luminous bands simultaneously, and exert pressure upon the eyeball, the luminous bands disappear upon *moderate* pressure, while the currents become more distinct. The pressure has to reach the point at which the function of the retina is almost suspended before the currents entirely disappear. Intermittent pressure often increases the distinctness with which the luminous bands are seen, and with this is combined a greater distinctness in their pulsatory movement. There are two modes in which the difference in the degree of pressure required to cause the disappearance of the luminous bands and the currents might be explained, according as the cause of the entoptic currents is supposed to be located in the retina or the chorio-capillaris.

a. If both phenomena are caused by the circulation of the blood in the retinal capillaries, then we may assume that the luminous bands are caused by the circulation in the finest capillaries, which are liable under normal conditions to obstruction, and consequently to collapse; while the currents can be supposed to be caused by the circulation in capillaries large enough to require abnormal tension of the eyeball to cause their collapse.

b. If it be assumed that the currents are caused by the

circulation in the chorio-capillaris, then the greater resistance of the sclerotica and the choroidea to pressure would explain the difficulty in causing the currents to disappear.

2. *The condition of the accommodation, and the relative positions of the visual axes of my eyes during the experiments for observing the entoptic currents and luminous bands.*

In order to determine the state of the accommodation and of the external muscles of the eye, I used a moderately illuminated, slightly roughened white surface; and used as the object of fixation a very fine vertical black line, or a small black dot.

It was thus only necessary to suddenly uncover the eye not used in order to detect the presence or absence of double images of the point or line; while the greater or less distinctness of the objects would determine with sufficient accuracy the state of the accommodation.

In this manner I determined that ordinarily, when the currents are most *clearly* and *easily* seen, either the eye used was accommodated for the distance of the luminous surface, and the axes of vision intersected at a different (nearer) point, or that the axes of vision crossing at the object observed, the eye was accommodated for a farther point; or, again, that neither the point of intersection of the axes of vision, nor the point for which the eye was accommodated, coincided with the point observed nor with each other.

3. *A new method of observing entoptically some of the larger retinal blood-vessels.*

If I look upon a bright sky, and at the same time press upon my eye with considerable force, an obscure, tremulous, pulsatory movement is observed. If the pressure be now increased, an entoptic figure of some of the larger retinal vessels is seen. The figure only remains momentarily visible, appearing first at the upper and lower margins of the optic papilla, as do the vessels seen entoptically by other methods. The figure presents the same brilliant white appearance as do the luminous bands. The appearance of the figure coincides in time with the pulse at the wrist. Upon repeating the experiment till my eye is fatigued and irritable, an indistinct pulsation and shadowy figure continues to appear for some time after the pressure upon the eye has ceased. If I then observed this in connection with the luminous bands, I found that their pulsatory movement was very decided, and coincided in time with the appearance of this figure, and with the pulse at the wrist. The short time that the figure remains visible renders a minute study difficult; but I am quite sure that only one set of vessels, either veins or arteries, are *directly* concerned. It is highly probable that changes occurring in the veins are the cause of this phenomenon. There are only two conceivable explanations of this appearance, viz.: either we must suppose that it is caused by the collapse of the veins, taking place with and caused by each pulsation of the central artery of the retina, or we must assume that it is a phenomenon in the nature of a phosphene, caused by the suddenly increased pressure of the column of blood in the arteries

along their course. If, as seems to be most probable, a collapse of the veins is the cause, it is easily explicable on the ground that by the sudden emptying of the veins, portions of the retina are exposed to a strong light, to which they are not habituated.

RECOVERY OF COMPLETE NERVOUS DEAFNESS.

By S. MOOS, M.D.

Translated by Dr. Joseph Aub, of Cincinnati.

Severe intracranial disease after acute rheumatism of the joints.—Peculiar nervous phenomena, combined with complete deafness for noises, musical tones, and speech.—Necessity of communicating with the patient in writing for several weeks.—Complete recovery.—A rare experience in favor of employing the constant current.

On the 10th of April, 1869, my friend and colleague Dr. Picot, of Carlsruhe, invited me to see a patient there, who had completely lost her hearing after a long and severe illness. I accepted this invitation on the 16th of the same month. *The following is the history of the case, as related by Dr. Picot:—*

Miss S. D., æt. 19, born of healthy parents, and who had never before been sick, took a severe cold on Feb. 9th, 1869, the result of a draught of air on a body overheated from dancing, and was confined to bed already on the following day. She had slight chills and shooting pains which spread all over the body, especially in the back; every movement was exceedingly painful, appetite disappeared, very great thirst, bowels

costive. The urine could not be voided from the 11th of Feb., but had to be drawn off with the catheter. After these symptoms had continued until the 15th of Feb., considerable swelling of all the joints of the right upper and lower extremities showed itself, combined with continued fever and great pain, making the diagnosis of acute rheumatism a certainty.

During four weeks the disease took its usual course; the fever was always moderate, temperature never rose above 39,5°C. The swelling of the joints in the right upper and lower extremities and in the vertebral joints remained unchanged; occasionally the joints of the left hand and foot were swollen. The pain was always very great (the extremities of the right side had to be laid like fractured limbs for a period of seven weeks). The patient was reposing on a water-bed, and only changed it three times during the seven weeks. During the first three weeks the urine had to be drawn with the catheter. Appetite small. Treatment: Cooling remedies, morph. internally and hypodermically. In the fourth week, with an exacerbation of the fever, a pleuritis on the right side showed itself, and disappeared after eight days.

At this time (in the fifth week), under continued affection of the joints, symptoms appeared which could only be considered as nervous (hysteric). With subsiding fever, better appetite and better digestion, she became gradually ill-humored, showing peculiarities and dislikes; then terrible pains in the right half of the body, excessive hyperæsthesia of the skin, reaching from the sixth rib to the crest of the ilium, and from the vertebræ to the linea alba, set in. The pains occurred periodically, at first 3–4 times a day, afterwards regularly from 12 to 1 o'clock at noon, and in the evening from 10–11, lasting 3–4 hours each time. At first the patient complained of violent burning, and attempted to conceal her pain with great self-command; soon, however, the pain proved stronger than the will of the patient, and she moaned and groaned uninterruptedly. After some time she would have a fainting-fit, lasting from 2–3 minutes, from which state she recovered with slight convulsions, only to continue her complaints. The attacks never ceased abruptly, but the pain gradually decreased, and left an excessive hyper-

æsthesia of that portion of the skin, which would hardly bear the contact of a camel's-hair brush.

For fourteen days all treatment proved futile in shortening the duration of these attacks. Warmth, cold, chloride of elayl, &c., &c., locally used, proved of no lasting benefit; later, in consequence of the great sensibility, it was impossible to use anything locally. During the first days injections of large doses of morphium procured some relief, not by shortening the attacks, but by causing a stupor. Chloroform—of which 120 grammes were given during an attack—only gave relief during the deepest narcosis. Finally, in the 7th week, the attacks became weaker, and disappeared altogether after an eight days' use of large doses of quinine and castoreum. During this period the swelling of the joints, which only remained on the right upper extremity, also gradually decreased; but in their place the following remarkable symptoms appeared in the extremities of the right side: During 7 weeks the nails had stopped growing, a slight excoriation of the skin (dating back to the ball) had not healed; when suddenly the epidermis on the extremities of the right side became detached in large patches, the nails grew with astonishing rapidity, the small lanugo-hair on the arm and leg changed into long black hair, and gave the emaciated hand and arm a peculiar appearance. (After the recovery of the patient the hair on the hand and arm, for cosmetic reasons, was removed by the use of depilatories, and by pulling it out; they did not recur. They still exist on the leg in great profusion, but up to date have not increased in length.)

At the end of the seventh week the patient complained of a terrible pain behind the left ear, on a place about the size of a hand; the left concha was very sensitive, and great hyperæsthesia of the left side of the face existed. *The organ of hearing now was very sensitive, every noise caused pain, the acuteness of hearing was very great.* As a sign of the increased acuteness, we need only mention that the patient understood every word of a conversation which was carried on in a subdued tone in a room on the floor above, and not directly over her bed (deception or fraud not being possible). At this time no anæsthesia was noticed, but immediately following. I must confess, however,

that at the time this acuteness of hearing existed, I did not examine for anæsthesia; when the acuteness subsided, the anæsthesia was very marked. The pains which were designated by the patient as *external*, occurred here as in the lumbar region, in periodical attacks, accompanied by the same symptoms (long continued fainting-fits and slight convulsions), and lasted from 2–3 hours, commencing regularly at 12–1 noon, and 10–11 P.M. The pain gradually decreases, but the hyperæsthesia continues always in such a degree that a hair touching the cheek causes unbearable pains. The attacks, on which morphium and opium had no influence, and which could be borne only in a chloroform-narcosis, disappeared after nine days' use of large doses of quinine. During these nine days the patient lay, without moving, on the right side, *and a considerable ulceration was developed on the right concha. The concha, as well as a spot of the width of two fingers before it, and one as large as a hand behind it, were totally anæsthetic.* The anæsthesia on the right side was complete before, on, and behind the ear. During the height of the disease a diminished sensitiveness for the needle could be proven up to the median line, also in the mucous membrane of the nose. The bladder had to be emptied again with the catheter.

In the eighth week, at length, reconvalescence seemed to set in: the affection of the joints had totally disappeared, no pain of any description existed; sleep, long unknown, was restored, appetite and digestion increased.

The decrease of the sensitiveness of the organ of hearing, however, was accompanied by hardness of hearing, which I was at first inclined to ascribe to the large doses of quinine.

The reconvalescence continued its favorable course, the patient sat up at the beginning of the ninth week, and recovered visibly from day to day. *Yet the hardness of hearing increased in such a degree that at the end of the ninth week she was perfectly deaf, and it was necessary to communicate with her in writing.* The examination of the ears gave a complete negative result, as well as a want of every sensation of

hearing, which was corroborated by my worthy friend Professor *Moos*, whom I called in consultation on the 16th of April.

The galvanic treatment of the ear, which was advised by the professor, had to be dispensed with until a suitable apparatus was procured; more so since the patient could not yet bear transportation.

On the 18th of April, in the 10th week, the patient complained of severe pains in the back, also, that when walking, her limbs nearly refused support, and of inability to urinate. Soon after she also had severe pain in the abdomen, in a region corresponding to the left ovary, in which place, later, a small hard tumor could be felt, deeply situated. The patient lost her appetite, and became very emaciated, without any fever. The pains were continuous, every treatment futile; even the palliative remedies could no longer be used, since morphium and chloroform, which up to this time had been borne very well, now caused severe vomiting.

In the 11th week (29th of April), after the patient had become gradually very moody through her absolute deafness and pains, she had a terrible hystero-epileptic attack; tetanic spasm of the whole body, with complete unconsciousness during 2¼ hours, until the trismus ceased, and clonic convulsions of ½ hour's duration ensued. From this time on she had 2–3 attacks of the same kind daily, lasting 1–1½ hours, preceded by an exacerbation of the pains in the abdomen and the back, loss of consciousness, tetanus, and at last clonic cramps. On the 3d of May she complained for the first time of very severe pain in the brain, on the left side, accompanied by excessive hyperæsthesia of the scalp. The hyperæsthesia of the scalp was decidedly unilateral—left—did not occupy the whole half of the head, the painfulness disappeared gradually towards the median line, was most severe behind the ear and on the back of the head. The skin of the face was in the same condition; the cheek and temple being especially hyperæsthetic, without, however, being ever so painful as the scalp.

All treatment was without success, until, on the 7th of May, I tried the constant current from 12 Meidinger's elements on the despairing patient. The result was a remarkable one. After 8 minutes (the

cathode in the nape of the neck, the anode remaining on the lumbar vertebra, and on a spot of the abdomen corresponding to the ovary) the pains in the back disappeared altogether for the space of $\frac{1}{2}$ hour. The menstruation, which had ceased for ten weeks, returned immediately after the galvanization. The following day I used a constant current of 5 Meidinger's elements, with the anode on the forehead and most painful spot, and the cathode in the nape of the neck, with very favorable results. Pain disappeared for 2 hours, and for the first time in weeks the patient had an hour's refreshing sleep immediately after the galvanization; this day she had only one slight attack. After this she was treated in the same way, with the current on the head and on the neck 2–3 times daily; there was no further attack.

It was never possible to remove the pain from that spot on the abdomen corresponding to the ovary. From the 5th of May the sympathetic nerve of the neck was galvanized daily for 3 minutes with 5 Meidinger's elements. Under galvanic treatment continued until the end of May—the first electric treatment of the ear taking place on the 11th of May—the pains gradually decrease and then disappear; during this time the patient had mimic contortions, lasting 24 hours, on the right side, continuing even during sleep, and also a tetanic cramp of the left forearm and hand, lasting 12 hours. On the 16th of May Profs. *Von Chelius* and *Kussmaul* were called in consultation; *we agreed that we had to deal with an extensive disturbance in the nutrition of the nervous centres.*

We agreed to continue the galvanization of the ear, resp. of the head. From the 17th of May the patient had very severe pains in the stomach, defying every treatment, disturbing the nutrition in a high degree, until the commencement of June, and thereby delaying the reconvalescence. On the 8th of June the patient went to Baden, having no trace of rheumatism of the joints, nor of nervous attacks, with the exception of the still existing anæsthesia of the right ear—(concerning the deafness, see further below.) During the summer she recovered perfectly, and now, the end of September, is as well as ever, all bodily and mental functions being in the best of order.

Although it is not within the scope of this journal to enter into elaborate details of clinical medicine, it has nevertheless been deemed necessary to consider somewhat more closely the clinical diagnosis of the entire disease, in order to form a more conclusive judgment as to what kind of nervous aural affection we had to deal with in the case before us. I believe that if it is at all possible to form an idea how the central organ of the nervous system was affected in our patient, the reader will readily do so after the perusal of the detailed and lucid report of our colleague Picot. Nevertheless it might be of interest to hear the opinion of Prof. *Kussmaul*, who was called in consultation, and kind enough to give me the following in writing, since I was not present on the occasion :—

"It seems to me that we are dealing here with a so-called rheumatic neurosis, extending over large portions of the central and peripheric nervous systems, which, still so little known, have only lately attracted the attention of the profession. I refer to the investigations of French physicians, *Lebert* and others, on the so-called cerebral rheumatism, as well as those of *Griesinger* and others on rheumatic psychoses. At any rate, the diagnosis of acute hysteria is not satisfactory, notwithstanding the many points of resemblance the case before us has with hysteria. This resemblance, however, should not astonish us when we consider that in hysteria as well as in rheumatism of the nerves we have minute changes of the tissues; that in both cases extensive portions can be attacked;

that in both the affection can change from one spot to another; finally, that in the case of our patient, as it seems, an ovary—perhaps its serosa, or the sero-fibrous coat—was affected by inflammatory rheumatism, which may have caused all kinds of reflex symptoms, of a truly hysterical character, and then mingled with those of a purely rheumatic nature. This department of nervous pathology yet awaits proper research, and still wants the first essential, a sufficient number of precise reports of cases."

Results of the examination of the organ of hearing in our patient.—Plan of treatment, and further course of the disease.

On the examination of the ear, on the 16th of April, I found: Anæsthesia of the right concha and external meatus, no reaction of the concha to the touch, nor of the meatus to the different movements and turnings of the speculum during the examination. Nothing abnormal, either in the external meatus or on the membrana tympani; the position and inclination of the membrane, its curvature, color, transparency, light-reflex, and mobility in the act of swallowing (the mouth and nose being closed), &c., were all normal. *On both sides non-conductibility of the bones for the tuning-fork, and for a watch having a hearing distance of thirty feet. We were enabled, however, by means of the double otoscope, to clearly distinguish the vibrations of the tuning-fork when placed on the bones of the head. Deafness for speech was of such a high degree that it was found necessary to communicate with the patient in writing. She is also unable to hear her own words.*

Taking these facts into consideration I felt myself justified in dispensing with the use of the catheter; so much the more so, since my colleague, Mr. Picot, had al-

ready made the manœuvre, thereby convincing himself of the permeability of the middle ear and of the uselessness of the catheter as a therapeutic agent. The patient complained of continued noises in both ears. Since she could not be moved, I recommended that an apparatus for the constant current be procured as soon as possible, and that she be treated systematically with it, expressing the opinion that if benefit was to be derived from any therapeutic agent, it would only be from the constant current of a battery.

Under these circumstances the *prognosis* would have been declared very *grave* by any physician, even if he was not much conversant with ear-diseases; for the aurist this became a duty, since the non-conductibility of the bones, even for such powerful sources of sound as were used for our patient, combined with a total want of abnormality of the middle ear, have to this day been considered as absolutely unfavorable symptoms by all otologists. During the further progress of the disease the prognosis became, if such a thing were within the range of possibility, even still more unfavorable; *for at the second consultation, on the 29th of April, it was found that even the subjective symptoms had totally disappeared, and it could no longer be doubted that there was a perfect paralysis of both auditory nerves.*

We were no longer at a loss as to the plan of the electric treatment. It was necessary to irritate the nerves of hearing as often and as strongly as possible. This was to be accomplished by the daily use of the constant current

with Volta's alternative (one electrode in the hand and the other in the corresponding external meatus, which was to be filled with lukewarm water. I use a vulcanized rubber ear-speculum plugged with cork for the ear-electrode. The metallic wire of the screw which is used for holding the ear-electrode passes through the cork stopper almost to the anterior end of the speculum). In case this treatment should lead to any favorable result, it was determined to continue by treating principally with the anode—the anode being placed in the ear and every reaction with the cathode being avoided.

When, at the end of the first week in May, the technical preliminaries for the application of the constant current had at length been completed, we found, as can be seen from the history of the case, independent complications on the left side. The hyperæsthesia of the left half of the head, which had made its appearance in the mean time, caused such an increased sensitiveness of the concha and external meatus that the patient complained of pain after the most careful introduction or moving of the ear-speculum. This increased on the application of the ear-electrode. We nevertheless insisted on this method of application, and so much the more so, since the other places considered eligible for the application of the second electrode in galvanization of the acusticus were for the most part hyperæsthetic. The electric examinations of both ears, made on the 9th and 10th of May, gave the following result:—

The right ear with 10 Meidinger's elements and 900 resistances of the current of the rheostat placed in the second closure gave on *cathode-closure* a lively whirring sound, which continued for a time during the duration of the cathode and then disappeared; the same result with 10 Meidinger's elements and 800 and 700 resistances of the current; with less resistances no result; further: *

	10 M.E.	900 C.R.	K.O.	—No result.
			An.S.—	"
			An.D.—	"
			An.O.—	"
Left ear:	10 M.E.	400 C.R.	K.S.	—Scratching of a violin.
			K.D.	—The same, lasting a short time.
			K.O.	—None.
			An.S.—	"
			An.D.—	"
			An.O.—	"

The same result with 10 M.E. and 350 and 300 resistances of the current; with 290 resistances, no more reaction.

Notes on the electric treatment of the ear, by Dr. Picot and Dr. Moos.

May 11*th*. *Right*: 10 M.E. KS. jarring, as if you are scratching a slate with a pencil, which continues during KD. In turning to the closing of the anode the sound increases, and becomes almost unbearable during the duration of the anode, leaving after-sounds of half a minute's duration after anode-opening. *Left*: with 6 El. same as right. Sensation=the scratching of a bad violin; during the An.O. after-perception of these sounds for 1½ minutes. Later no more subjective noises.

May 12*th*. Right 4 El. no reaction. 8 El. same reaction as yester-

* For explanations of these abbreviations, see Archives of Ophth. and Otol., Vol. I., No. 1, p. 242.

day with 10. Later the same reaction produced by 4 El. Left: 2 El. no reaction. 4 El. same as yesterday.

May 14th. Patient feels too miserable to allow of any treatment.

May 15th. Right ear 4 El., no reaction. 6 El. *noises during KS. and KD.* Stronger during An.S. and An.D. *Also on the ear not experimented on, namely, paradoxical reaction.* With 4 El. the same sensations, though weaker in all phases, but without any paradoxical symptoms. Left: same as on the 13th of May.

May 16th. Right: same as on May 15th. Left: 2 El., no reaction. 4 El. KS. weak, during KD. loud tones, as on May 11th. *Paradoxical sensations.*

May 17th. Right: same as on the day before. Left: 2 El. KS. sounds, which increase on changing to An.S. and during An.D. No paradoxical sensation.

May 18th. Right: 4 El., KS. and KD. passing sounds which are prolonged with 5 El. KD. An.S. and An.D. loud noises with after-tones on An.O. Left: 2 El. no reaction with the cathode. Sounds with An.S. and during An.D., with 3 El. reaction in both phases. The duration of each examination was from 2–2½ minutes with from 4–5 times change of the current.

May 19th. Right: the same as on May 18th. Left: with 2 El., weak reaction with An.S. and during An.D. Otherwise same as on May 18th. *Paradoxical sensation.*

May 21st. Right: with 2 El. no reaction; with 4 El. reaction with KS., KD., An.S., An.D., and An.O., the same as on May 18th. *Paradoxical sensations.* Left: 4 El. KS. and KD. Prolonged sounding, which increases with the An.S., combined with the paradoxical sensation on the other ear. An O. also produces reaction. With 2 El. reaction only in KS. *Our patient has subjective symptoms for the first time to-day, at an hour not used for galvanic treatment.*

May 22d. = *May 21st. The patient hears her own voice with the left ear during and immediately after the galvanic treatment.*

May 23d. Patient hears her voice with the right ear.

May 24th. Same as yesterday; patient hears her own voice with

both ears during the treatment, *and also during the rest of the day. Experiments with whistling give a negative result.*

May 25*th*, 26*th*, 27*th*, 28*th*, 29*th*, and 30*th*. Always the same galvanic reaction, with KS. and KD. weak, with An.S. and An.D. strong sounding. Reaction on breaking the current could never be confirmed. May 27th. Hears deep speech by means of the hearing-trumpet. May 28th. Understands deeply spoken (roared) short words. May 29th. Understands without a trumpet when we speak slowly, syllable by syllable, and in a bass voice close to the ear. Galvanization diminishes the subjective noises in the ear only temporarily. May 30th. Improvement of the power of hearing. For galvanization we use only 2–3 El. on both ears. It seems as if we also had reaction on An.O., although this cannot be positively affirmed.

May 31*st*. All the same.

June 1*st*. Galvanic symptoms as above. We now notice also plainly perceptible reactions with KO., and more plain with An.O. The latter are the stronger. The power of hearing increases. The patient understands now the voice of her little sister, and can hear the rolling of the wagons on the street.

June 2*d*. The same conditions.

June 3*d*.–Examination with the Rheostat by Dr. Moos. Right ear 5 M. El. 190 C.R., KS., and An.S., no reaction.

5 M. El. 200 C.R., KS. sounding.
KD. gradually decreasing.
KO. sounding.
An.S. sounding, but weaker than with KS.
An.D. the same.
An.O. the same.

Left ear 5 M. El., 50 C.R. KS., etc., no reaction.

5 " 60 C.R. positive result in all phases, as right.

June 4*th*. With from 1–3 El. the patient distinguishes plain sounding with KS., KD., KO., AS., AD., AO. The D. = sensations are, according to her statement, much weaker than those of

the S. and O. The patient positively asserts that the sounds at the closing and opening of the current are of different pitch, KS. being of the lowest pitch and An.O. the highest. With KS. a deep tone, KD. deep buzzing, KO. a deep tone, yet not so deep as with KS., An.S. very high sharp tone, AD. ringing, AO. high tone (highest of all). This formula is accurately repeated during the next eight days with the same strength of current. The sensation of sound is so acute that she says it is even painful. The noises diminish gradually in KD., and especially in An.D., but never totally disappear.

June 5th. Exactly as on June 4th; no inconsiderable improvement of hearing. Listening to even rapid speaking does not tire the patient so easily.

June 6th, 7th, 8th. Treatment only in the anode with 2–4 El. Under this treatment the severe subjective noises diminish, never disappear, and return after a short time more severe than before.

June 9th. No treatment. From now treatment every third day only.

From June 10th to 25th. Patient lived in Baden Baden. Continuance of treatment by Dr. Picot and Dr. Von Kraft-Ebing. June 10th. Formula same as June 4th. To-day the noises disappeared entirely in the right ear during treatment, in the left ear nearly so. After the treatment patient has no noises for two and a half hours. The acusticus is less hyperæsthetic. The sensations of sound during galvanization are not so painful. June 13th. Anode during four minutes. Noise disappears in the right ear altogether for two and a half hours.

June 15th. Treatment with the anode. Noise disappears in both ears; right for four hours, left, half an hour.

June 17th. Anode treatment. Noise disappears in both ears. With 4 El. the following formula:—

KS. loud sounding.
KD. ∞.
KO. fine sounding.
AS. no reaction.
An.D. no reaction.
AO. soundings.

From the 18th–24th of June. Daily treatment with the anode. On June 20th, *conductibility of the bones was noticed for the first time.* The watch both sides 2–3 inches. Hearing of speech: Right, four feet; left, two feet. The power of hearing increases slowly but steadily. Hearing is better immediately after the galvanization, when there are no noises. From June 23d no more noises in the right ear.

June 25. Return to Karlsruhe.

June 26. Anode treatment of both ears with from 2–5 El. Right, no more noises; left, they disappear for 24 hours after the treatment. Improvement of hearing.

June 27. Anode treatment of the left ear. Noise disappears for 36 hours.

June 29. Anode treatment of the left ear. The noise disappears until the evening of July 1st, a total of about 50 hours. Improvement of hearing.

July 2. Anode treatment of the left ear. Noises disappear altogether. Dizziness.

July 4. Patient went to Heidelberg. The examination by Dr. Moos showed:—

Hearing distance for watch (30 feet): Right, 40; left, 24 inches. Hearing of speech: Right and left three paces. Conductibility of bones for watch and tuning-forks; the latter, those of high as well as those of low pitch, are heard either through the conduction of the bones or the air, more distinctly right than left. The examination, as to the perception of single notes of the musical scale, shows in the right ear deafness for the two highest, and in the left for the five highest notes of the 7-octave piano. The patient has no more subjective noises. Anæsthesia of the right concha and its immediate surroundings. Normal formula on the use of 12 Siemens-Halske's modified El. and 160 C.R. right, and 280 C.R. left. Patient asserts that she hears a sound of medium pitch, but that on the right ear it is pure and clear, while on the left it is muffled. Immediately after the galvanization, watch was heard, right, 47, and left, 27 inches; speech, both ears, 5 paces.

July 5–11*th*. Daily treatment in Karlsruhe for 1–1½ minute with

2–4 El. in the anode. No noises. Increase of sensibility for the current in the external meatus; sensation of burning. No sensation of sound during treatment. At each sitting frightful dizziness. Hearing improves daily.

July 3.	Right 31,	left 20	Cm.	for	the	watch.
" 5.	" 41,	" 30	"	"	"	
" 8.	" 61,	" 50	"	"	"	
" 10.	" 100,	" 90	"	"	"	
" 12.	" 126,	" 113	"	"	"	
" 15.	" 168,	" 140	"	"	"	

The hearing of speech has increased proportionately.

July 12. Patient visited Heidelberg, and was examined by Dr. Moos. Hearing distance for the watch (30 feet): Right, 10 feet; left, 9 feet. Whispered voice: Right, 4; left, 3 paces. Conductibility of the bones for a finer watch; right plainer than left. In whispered speech the patient hears words with the sound *Ah*, as "Are," "Father," a few paces further than words with the sound *A* as in "Fate," "Ape," etc. Tuning-fork: Right clearer than left, but the difference is not so marked as on July 4th. No subjective sensations of sound. Frightful dizziness on the use of 9 Siemens-Halske's El.; the same symptoms at the second trial, after a pause of several minutes, with 3 S. H. El., and only 10 resistances of the current of the rheostat in the secondary closure. The dizziness nevertheless was of such a frightful character that it was considered advisable to desist from any further galvanization of the ear, resp. the head.

The same violent symptoms occurring in Karlsruhe the next day, after a treatment of ¼ minute with 3 El., the patient could consequently, during the next fortnight, be treated only 4 times, and then with very weak currents. July 27th, patient was sent to spend 6 weeks in the Black Forest. There she recovered completely. The last examination made by Dr. Moos, on the 21st of Sept., in Heidelberg, gave the following result:—

Normal acuteness of hearing for a cylinder-watch of 6 feet hearing distance: Right, still inability to distinguish the highest note of the 7-

octave piano. Otherwise hearing is altogether normal. Subjective sensations of sound have not been felt since many weeks. On the left side no anomaly of the sensation of touch. On the right side, notwithstanding an electro-cutaneous treatment, continued for some time, no entirely normal sensation of touch; besides this the following spots are still anæsthetic: the lobules, and a triangular spot, immediately below it, having its apex turned towards the lower jaw, the helix and the upper portion of the fossa triangularis.

Remarks of Dr. Moos.

The case just described offers us many points of remarkable interest.

1. *From the different forms of the disease of the organ of hearing.* On the right side: Paralysis of the auditory nerve, paralysis of the sense of touch, as well as paralysis of the trophic nerves—decubitus of the right concha. On the left side: Paralysis of the nerve of hearing, long-continued hyperæsthesia of the nerves of touch. *All the symptoms* taken in connection with the entire history of the case may be said to have been the result of some *cerebral lesion.* It is true the decubitus of the right concha was in a high degree favored by the continued lying during nine days on the right side. *The stage of paralysis was preceded by a period of increased irritability.* This showed itself by an enormous increase of sensitiveness for all sounds, as well as by a remarkable increase in the acuity of hearing. Perhaps the former was the result of a paralysis, existing at the same time, of that branch of the trigeminus * which goes to the tensor tym-

* See (Beitraege zur Physiologie des Gehoerganges, von Dr. Ad. Politzer).

pani. The latter was, without doubt, a consequence and one of the first symptoms of the beginning participation of the auditory nerve in the intracranial process.

2. *From the manner in which the function of the auditory nerve was entirely suspended.* After the sensation of sounds for objective irritations of every kind had totally ceased the subjective sensations of hearing disappeared also, and remained quiet for several weeks, a striking proof of the complete paralysis of the nerve. For, according to the present standpoint of the study of illusions, it is laid down as a positive rule, that in order to promulgate the existence of a hallucination the integrity of the organ of sense is not requisite, but that the origin of an illusion is absolutely impossible without the aid of an organ of sense.*

A subjective sensation of a nerve of special sense whose function is paralyzed always presupposes at least the possibility of an irritation in the nerve itself by means of pathological changes, but entirely independent of things external to it. A total destruction of the func-

Ueber die Innervation der Binnenmuskeln des Ohres u. s. w. Sitzungsberichte der Wien. Akademie vom 14. Maerz 1861. From the quoted experiments of Politzer we deduce, that the tensor tympani is supplied by the Pars motoria nervi quinti. Helmholtz believes that the tensor tympani has a function analogous to the iris. Perhaps it produces a muffling of the sound. See: Mittheilungen ueber die Mechanik der Gehoerknoechelchen in den Verhandlungen des Heidelberg. Naturhistorisch. Medicinischen Vereins, Jahrgang 1867.

* Compare Wachsmuth: Pathologie der Seele, § 73, and Griesinger: Pathologie und Therapie der psychischen Krankheiten, § 88, II. ed.; besides my essay: Ueber ploetzlich entstandene Taubheit, in the Wien. Mediz. Wochenschrift, 1863, N. 41, 42, 43.

tion, combined with a want of every subjective sensation, is proof positive of the complete paralysis of the sensory nerve.

3. *From the symptoms on the examination and treatment by means of the constant current.*

a. Although a paralysis of the trigeminus existed on the right side, it was nevertheless possible to produce an electric irritation of the acusticus. Notwithstanding the paralysis of the trigeminus in the right side, the irritability of the paralyzed sensory nerve of the same side was continually increased, and finally brought to a perfect recovery by means of the electric current. This proves that in the production of the sensations of sound by galvanization, the promulgation of the irritation is not produced from the ends of the trigeminus, a fact which Brenner,* contrary to the assertions of many other observers,† has clearly proven.

b. Although the auditory nerve was totally insensible to sounds of any kind, it nevertheless showed reaction to electric irritants, even at the moment of greatest deafness.‡

* Compare: Untersuchungen und Beobachtungen auf dem Gebiete der Elektro-Therapie, Bd. I., Abth. I., S. 95-97.

† Among these observers are Schulz and Benedikt. The principal reason why Benedikt believed in a reflex irritation, "was the observation that, cet. par.—e. g., with a sensitive trigeminus—the subjective sensations at least are often noticed with less powerful currents than with a non-sensitive trigeminus" (his Elektrotherapie, p. 270). This observation was confirmed with our patient; but we see from the facts mentioned in 3, that the correct observation of Benedikt cannot be a conclusive proof for his opinion.

‡ This fact must appear natural to every physician acquainted with the

c. As regards the single reactions on the use of the constant current, the acoustic nerve showed, during the different periods of the disease, different kinds of reactions, but not a single one which had not been previously clearly and minutely described by *Brenner* (l. c.). In this respect the entire history of this case only gives additional proof of the reliability of this observer, and especially as regards those observations laid down in the work above cited.*

In the first days we had only a weak reaction of the auditory nerve† with the cathode. Then followed a *period of simple hyperæsthesia* combined with what *Brenner* calls "*paradoxical reaction*" (l. c., p. 401), and finally, a *period of hyperæsthesia with qualitative change* of the formula combined with paradoxical reaction. Only after a long-continued treatment in the duration of the anode did we have a stage with the character of simple hyperæsthesia, and finally, at the time of recovery, the normal formula put down by *Brenner*.

I consider it my duty, on account of the suspicions as regards the accuracy of *Brenner's* observations, to call your special attention to the notes made by my colleague

A B C of the physiology of nerves. Nevertheless it must be urged in opposition to the statements of some aurists.

* I deem it therefore especially important to point to the fact that the electric treatment was conducted by *Dr. Picot.* The Dr. had, up to this time, never treated an ear-patient with electricity; he treated the patient as agreed upon, and took his notes daily, a portion of them before he was acquainted with the monograph of *Brenner.*

† In the commencement we only noticed very undefined subjective sensations of sound, without any character of resonance; then they were called "noises," and only later were they recognized as real "tones."

Picot (especially page 476, May 15), and to compare them with the following remarks of Brenner:—" *Hyperæsthesia with paradoxical formulæ of the ear not under treatment.* The ear not treated reacts exactly as if it were under the influence of the other electrode. In order to produce the reaction in the ear not treated, it is in most cases necessary to use a stronger current than is necessary to produce a reaction in the ear under treatment, or, in other words, there is a minimum strength of current under which the symptom now being discussed does not show itself, and then we only have simple hyperæsthesia. This most remarkable symptom is in most cases combined with a very high degree of hyperæsthesia; but I have also observed it in cases of very little increased irritability. This condition excites the highest interest in such cases where it is complicated with a qualitative change in the formula of reaction. In all cases, but especially in the latter, the superficial observer sees only a seemingly inextricable chaos of sensations of sound; for each of the different movements of irritation is answered by one or both ears, &c."—S. l. c., p. 201, 202, and the following.

We observe: All assertions of *Brenner* are confirmed in our patient; the only exception in this instance is, that the disease is not of long standing, whilst *Brenner*, p. 201, says:—" I have only found this symptom (hyperæsthesia with paradoxical formula of the ear not under treatment) in cases of very old and very serious affection of the organ of hearing." *Brenner* found it very fre-

quently. I myself have until now found it only in positively nervous diseases of the ear, most frequently in deafness after cerebro-spinal meningitis. We will be able to use it, perhaps, at some future time as a diagnostic sign; I myself would not dare to hint under what circumstances. This condition does not give any hints as to the prognosis; I found it even in cases of incurable nervous deafness.

d. *From the beneficial influence of the treatment by duration of the anode, on the subjective sensations of sound.* In the commencement these were only silent during the duration of the anode, only to return after its opening; later they were also silent for several hours after the treatment, and finally they disappeared altogether. We must mention, although it was only exceptional, the fact that once the cathode also seemed to exercise a temporary beneficial influence on the subjective sensations of hearing.

e. *From the violent attacks of dizziness which, notwithstanding all the precautions taken as to the position of the electrodes and the strength of the currents used, occurred in the last days of the treatment. Brenner* asserts, with regard to this symptom on the application of the electrodes to the head (l. c., p. 75):—"It is, however, not altogether indifferent how you apply the electrodes to the head when you wish to produce this symptom. You will never produce a dizziness, no matter on what part of the head you close the chain, as long as the imaginary line which connects the two electrodes runs parallel with

the plane which the long axis of the body forms with the long axis of the skull. For the existence of this dizziness it is requisite that the line joining the two electrodes shall form an angle with that plane; and the effect is greatest when the angle is a right one. We conclude from this that the most favorable position of the electrodes for the production of this dizziness is that in which the one corresponds to one half, the other to the other half of the skull. For it is true that the dizziness ceases as soon as the one electrode, in approaching the other, crosses the median line of the skull. *The loss of balance follows, without exception, in the direction which corresponds to the anode.*"

Although I drew *Dr. Picot's* attention to the precautions mentioned by *Brenner*, and I myself followed his directions most precisely, we nevertheless had terrible dizziness. This occurred even in the examination of July 12, when I used the *weakest* current in my apparatus, viz., 3El., and 10 resistances of the current. Was the increased disposition to sensations of dizziness the result of long duration of the galvanization of the head, which was done towards the last only with the anode? Whatever the cause, we can deduce from it the necessity of exercising the greatest caution, and if the case is not very urgent, have intervals of several days during the treatment, as we did towards the last with our patient.

4. *From the manner in which the function of the auditory nerve returned.* In this respect we think the following worthy of mention: The patient first perceived

marked subjective sensations of sound immediately after the use of the current, May 21. These were afterwards present even during the pauses. *The appearance of subjective sensations of hearing, which, as accompanying symptoms of a disease of the ear, have formerly been considered unfavorable for the prognosis, may therefore be, according to circumstances, a favorable symptom in cases of total nervous deafness.* Subsequently, the patient heard her own voice (May 22d) *immediately after* the treatment on the left ear, and May 23, on both ears. May 24, she hears her own voice at times during the day *when not under treatment.* May 27, for the first time, *deep sounds through the trumpet;* on the 29th, without the *trumpet*, and on June 1st, distant noises and high voices. Subsequently the conductibility of the bones returned, and finally, *the highest notes of the musical scale* were also distinguished. The want of conductibility of the bones, even for powerful sources of sound, when the middle ear is intact, can therefore not be considered as absolutely unfavorable, but its return must naturally be considered favorable. All these are symptoms which, from a physiological point of view, must be considered worthy of mention, but need no comment on my part. Finally, we must mention the fact, that even on the day of treatment we could always find a measurable improvement in the acuity of the hearing power, and at last *the improvement and entire removal of all other nervous symptoms* (not belonging to the organ of hearing). In short, *a complete recovery was effected under the use of*

the constant current, with the exception of the anæsthesia of the right ear and its neighborhood, more minutely described above.

Concluding Remarks.

The careful reader will have noticed that in every place, as well in the heading as at the end, I have carefully avoided using the words Cure or Recovery *by* the constant current. Criticism will find in this case a very large field to display itself, more especially because, according to the present standpoint of our knowledge of nervous affections, it is impossible to make a special diagnosis in the disease before us. He who agrees with the altogether general diagnosis of Prof. Kussmaul—I myself have not the slightest idea of differing from it, because to me it seems the most plausible and probable—might observe with the greatest ease: "We were dealing here with an acute rheumatic, or a hysterical, or a rheumatic-hysterical affection of the nervous system, which would have healed spontaneously; the use of the constant current was, therefore, altogether irrelevant. The *vis medicatrix naturæ*, without which the physician in his character as healing artist would be a cipher, has done everything here," &c. This observation I would answer with the generally adopted principle, that *where there is a healing by nature there is also a healing by art*, and I believe that much credit must be given to the effect of the constant current, after a careful and unprejudiced perusal of the history of the case; I believe also that this will be

done by the majority of physicians, who in similar cases —which, it is true, do not occur frequently—will gladly avail themselves of the benefit to be derived from the use of the constant current.

Among the aurists, of course, matters look very differently. Some of them, demigods in their own estimation, and enjoying in certain even scientific circles (probably not much longer) a blind reputation as authorities, have only shown scorn for, or preserved a dignified silence about electro-otiatrics. On the other hand, they have never wearied in filling entire pages in print by upbraiding general practitioners for neglecting the study of ear-diseases.

May this case toll the funeral knell for all those opponents of a therapeutic agent which, when employed according to proper indications, may yet prove a rational and grateful means not only for certain muscular and nervous affections, but also for some ear diseases, though their number may be limited.

MELANOTIC SARCOMA OF THE CILIARY BODY AND ADJOINING CHOROID.

By H. KNAPP.

B. Reinle, seventy-three years old, a healthy-looking widow woman of Schwetzingen, experienced, six weeks ago, some pain in her right eye, and, on closing the left, was surprised to find that she saw very little with the right. The pain increased, the eye became red, and its sight diminished still more, until she presented herself at my clinic in Heidelberg, the 30th of June, 1868. The eye was very much irritated, painful to the touch, and intolerant of light. A great many dilated and tortuous vessels branched over the sclerotic; the conjunctiva, however, was not swollen. The cornea sensible and transparent, anterior chamber of normal size, its contents clear, iris discolored and highly vascular; a number of red streaks radiating from its periphery towards the pupil, enlarging here and there into red round specks. A great many synechiæ united the whole pupillary border of the iris with the anterior capsule, and rendered the latter quite opaque by expanding as a grayish film throughout the pupillary space. Atropine produced no dilatation of the pupil. The tension of the globe was but very slightly increased. There was evident narrowing of the field of vision towards the nose, but its limits could not be determined exactly, the patient being scarcely able to count fingers.

The *diagnosis* was left uncertain. A laxative was administered, leeches were applied to the right temple, and a drop of atropine was

instilled every two hours. The patient remained in bed. Two days later the irritation had subsided considerably, the redness diminished, the pupil was clearing up, and a little dilated towards the nose, the blood-vessels of the anterior surface of the iris had mostly disappeared, the pain was less, the tension of the globe remained the same, the sight had improved to the capacity of counting fingers at three feet distance, and the narrowing of the visual field was better defined. *At the outer ciliary border a detachment of the iris was observed* having 4 mm. in length and about 1½ to 2 mm. in breadth. This *iridodialysis* must have occurred during the preceding night, for the patient had been carefully examined by oblique light every day, and the detachment was so evident that it could not possibly have been overlooked. Nothing was distinguishable in or through the opening made by the dialysis, and the adjoining part of the iris appeared quite normal. With focal illumination a *dark yellowish swelling was clearly perceptible at the outer part of the ciliary region*, close behind the transparent lens, and behind the iridodialysis. It projected with a marked circular outline into the vitreous chamber. On ophthalmoscopic examination the inner half of the pupillary field reflected a dim reddish light, whereas the outer half was entirely dark.

The patient remained under treatment a week longer. The pain in her eye never completely ceased; the vessels continued large and tortuous; the pupil and vitreous chamber did not clear up any further; sight became worse again; and the visual field, when examined with the hand, contracted almost to the point of fixation. In this state I deemed it improbable that longer observation would furnish any additional diagnostic data.

On the 9th of July the patient was examined in the clinic. The symptoms were as above related, and out of their combination the definite diagnosis of *melanotic sarcoma of the ciliary region and adjoining choroid* was derived. Other diseases for which the case might have

been mistaken were discussed. They were, briefly enumerated, the following:—

1. *Glaucomatous Irido-choroiditis.*—The slight increase of tension, the episcleral injection, the restraint of the visual field towards the nose, the dulness of the vitreous chamber, the diminution of sight, the pain, and the sudden appearance of the disease, seven weeks ago, were all arguments in favor of glaucomatous inflammation. But neither the distinct appearance of a yellowish mass at the outer part of the vitreous chamber, nor the spontaneous iridodialysis could be explained by primary glaucoma.

2. *Detachment of the Retina.*—In favor of which spoke the narrowing of the visual field and the spherical opacity in the outer part of the vitreous chamber. But no floating of the retina, none of its characteristic vessels, no decrease of intraocular pressure, and none of the diseases known to induce retinal detachment, could be recognized.

3. *Abscess in Ciliary Region.*—This is not unfrequently met with under symptoms similar to those present in our case. Injuries and foreign bodies in this region cause it very commonly. But the patient had met with no accident, and primary abscess in the ciliary region is extremely rare. I have seen, however, one case in which there was a spontaneous collection of pus exactly in the same region where the swelling appeared in our patient, with this difference, that its color was a brilliant yellow instead of being dusky and opaque.

I enucleated the eyeball. The wound healed by first intention, and the patient was dismissed six days after the operation, free from suffering. She remained under my observation till the end of my stay in Heidelberg, Oct. 1, 1868; but I could not find anything abnormal in her orbit, nor in her general system either.

Anatomical examination of the extirpated eyeball. The freshly enucleated globe, when turned toward a gas-light, proved transparent in its inner half, but opaque in the outer. By turning it around, a dark body, about the size of a hazel-nut, could be seen in the outer portion of the ciliary region and adjoining choroid. I divided the eyeball by an antero-posterior section corresponding to the vertical meridian. Cornea, aqueous humor, and crystalline lens were normal, the vitreous body diffusely opaque, with gray membranes and filaments passing through it. The retina was everywhere adherent to the choroid, and showed no alteration. At the outer part of the *ciliary region and choroid a hemispherical tumor, the size of a hazel-nut,* was seated. Its surface was smooth, black, and shining, being uninterruptedly covered with the membrana ciliaris retinæ, which was continuous with the posterior surface of the apparently healthy iris.

In order to obtain good sections through the tumor and its connecting parts, I hardened the eyeball in Müller's fluid (2 parts of bichromate of potash; 1 part of sulphate of soda; 100 parts of distilled water), and four months afterwards examined it minutely.

The *retina* was normal, and covered more than the

posterior half of the tumor. In the other hemisphere a thin, perfectly transparent, *homogeneous membrane, extending across the vitreous chamber, parallel to the plain of the equator*, was recognized. It was attached to the retina in a circle lying at all points 3 mm. behind the ora serrata, and its insertion was so firm that by drawing on it I was able to separate the retina from the choroid as far as the ora serrata. This false membrane consisted of the finest anastomosing net of large uni- and multinuclear stellate corpuscles, interspersed with physaliphorous cells. In some places the stellate cells lay closer together, and more nearly parallel, so as to form a denser connective tissue. The whole new formation in the vitreous body was a reproduction of its embryonic state, *Virchow's* mucous tissue.

On the surface of the tumor lay a discontinuous, fragile, filamentous covering; the same was found also in some places between retina and choroid, and proved to be granular and filamentous fibrinous deposit.

The *ciliary processes* were everywhere sharply defined, much shortened however at the anterior margin of the tumor, so that all parts of them, except their apices, were lost in the pseudo plasma. The latter had advanced on the outer side of the ciliary processes, and formed an organic union with the peripheral portion of the iris.

After dividing the growth through the middle, I found its antero-posterior diameter to be 14 mm.; transverse diameter 12,3 mm., and thickness 11 mm.

The *cut surface* was granular and black, except on an egg-shaped portion at the outer and anterior part, which was whitish, 7 by 5,5 mm. large, lying like a nucleus embedded in the black mass, which was thinnest (1,3 mm. only) between this nucleus and the sclerotic.

By drawing the cornea backwards the *relations between the tumor and the iris* were discernible. In a small extent of about 2,3 mm. in length, and 1 mm. in breadth, the iris was separated from its sclerotical insertion-line, and united with the tumor in such manner that it seemed to originate in the latter. The defect caused by this detachment was, on the background, filled out with the foreign growth.

The *pseudo-plasma was in uninterrupted connection with the choroid*, out of which it arose in the form of a round, thoroughly circumscribed tumor. The choroid presented nowhere else any abnormities. The retina could easily be detached from the tumor as far as the ora serrata, which adhered to the anterior half of the intumescence.

The *neoplasma was closely connected with the sclerotic*, the lamellæ of which nowhere appeared invaded by it.

Microscopic examination showed the tumor to be a *typical specimen of melanotic sarcoma.* The majority of the cells were spindle-shaped; the processes of many, however, were so delicate that they were broken off by manipulation. In the whitish oval portion the cells had the same character, but were mostly destitute of pigment. In no place was I able to detect any muscular

elements derived from the ciliary ligament, the fusiform cells of the growth distinguishing themselves from smooth muscular fibres by the roundness of their nuclei and the brilliancy of their nucleoli. The ciliary muscle may, therefore, be considered as having been destroyed by the pseudo-plasma. The cells of the latter were largely in excess of the homogeneous intercellular substance, and its bulk was but scantily supplied with blood-vessels.

Origin of the growth and *mode of its progress.* Sections through the margin of the tumor and a part of the neighboring choroid showed that abundant *hyperplasy of pigmented fusiform and oval cells took place from the outer choroidal layers,* without the usual interposition of lymphoid cells. The inner layers of the choroid were preserved and covered the growth to a great extent. The most anterior part of the retina, lying loosely upon the tumor, was in a state of chronic plastic inflammation, presenting augmentation of its connective tissue and infiltration with lymphoid bodies. The sclerotic was closely united to the tumor, so that no interstitial tissue lay between its fibrous bundles and the elements of the neoplasma. In some places, however, rows of small round cells were crowded between the fibre-bundles of the sclerotic, indicating an incipient encroachment of the sarcoma tissue on the sclerotic. Most important was the examination of the anterior portion of the globe, because of its diagnostic value. The inner part of the sclerotic was lined with a dense melanotic mass, extending as far for-

ward as the internal margin of the cornea. There it ceased abruptly, but projected with a smooth surface inwardly, towards the axis of the globe. About 1,3 mm. from the sclerotic, the iris emerged from the black intumescence. Its substance was softened, swollen, and largely interspersed with lymphoid cells—a state of hyperæmia and serous and lymphoid infiltration, which had been noticed already in the living eye, constituting the first stage of inflammation. At the inner angle of the anterior surface of the tumor, a little inwards from the origin of the iris, the stunted ciliary processes were recognized. Their pigment layer was entirely preserved, as well as the connective tissue enveloping the blood-vessels in the interior of the processes. Their vessels were numerous, and connected with those of the external layers of the tumor. They were encompassed in many places by a dense accumulation of lymphoid cells, many of which manifested themselves as sarcoma-cells, having but very small zones of protoplasma around their large nuclei. In addition to their morphological distinctive features, their gradual transition or development into large, well-characterized sarcoma-cells was clearly discernible.

To *review briefly the description of this case:* We find the patient losing her sight under symptoms of internal ophthalmia. The cloudiness of the refracting media, and obstruction of the pupillary field by plastic exudation, made the examination with the ophthalmoscope impossible. Antiphlogistic treatment cleared the refracting media a little, sight improved slightly, a defect of the

field of vision toward the nose was stated, and with oblique light a dark yellowish lump was observed to project from the outer ciliary region toward the optical axis. At this time the iris, just in front of this lump, became detached from the sclerotic, but no pathological formation was recognized to fill out the opening. Upon these data the diagnosis of a melanotic sarcoma of the ciliary body and adjoining choroid was based, which had just passed from its first non-irritative stage into the second, that of glaucomatous inflammation. Melanosis was presumed on account of the dark color of the globular mass within the eye and the age of the patient, choroidal sarcoma in elderly people being probably always of the melanotic variety. The increasing tumor had involved the peripheral portion of the iris, detached it from the sclerotic, and drawn it inwardly. The tumor was a spindle-shaped pigmented sarcoma; its origin the outer layer of the choroid and ciliary body. Its increase followed both modes we observe in neoplasms generally, that of *embryonic development* by infiltration with lymphoid cells (*Virchow's* indifferent or granulation stage), and that of *physiological growth*, multiplication of elements of the mother tissue.

The *peculiar and remarkable features* of this case were, 1. *The detachment of the iris* by the inwardly tending growth. When choroidal sarcoma extends to the ciliary body, its elements crowd forward between the sclerotic and ciliary muscle, throwing the latter, as well as the ciliary processes and their continuation, the iris, towards

the optic axis. Through the opening made in this way, the pseudo-plasma enters the anterior chamber. 2. The *total adhesion of the retina* to the choroid and the tumor, a fact which is at variance with the common belief that detachment of the retina is one of the earliest consequences of intra-ocular tumors. 3. The *formation of a large transparent membrane across the vitreous space, parallel to the plane of the equator*, and firmly connected with the retina, its histologic elements being those of the embryonic stage of the vitreous body, namely, mucous tissue, interspersed with a large quantity of physaliphorous cells.

ON THE PATHOLOGY OF THE VITREOUS.

By Dr. HERMAN PAGENSTECHER, OF WIESBADEN.

Translated from the German by J. H. Pooley, M.D., of Yonkers, N. Y.

On the Question of Inflammation of the Vitreous.

As the views regarding the normal structure of the vitreous have always been an object of earnest discussion, and as it appears the various experiments have not yet led to any definite conclusion, it can only be regarded as a natural consequence if in reference to its pathological actions the most striking differences of opinion have prevailed. Here there were not questions which had reference only to unimportant conditions; no, even such questions were under discussion as might place the whole subject of the pathological changes of the vitreous in a new light. Thus the different investigations on the question of inflammation of the vitreous did not only seek to ascertain how, that is, out of what cell elements the products of inflammation are developed, but they even endeavored to prove that the vitreous is not capable of inflammation at all.

The latter view, formerly defended by *Stellwag*, and in

the year 1860 also by *Ritter*,* was very soon lost sight of. The often-cited treatise by *C. O. Weber*,† the treatise of *Coccius*,‡ and the clinical contributions which have been produced by different authors, seemed to have proved fully the possibility of the existence of an idiopathic *hyalitis* ending in suppuration. It was believed that the existence of connective tissue had been proved, or at least the existence of cells from which pus corpuscles might be produced. This view became immediately so universal that when, in the year 1864, the question was proposed to the Congress in Paris, the most eminent observers present expressed themselves fully in favor of it. Even *Iwanoff* could at that time by his researches upon the normal and pathological anatomy of the eye only arrive at similar conclusions.

Thus it happened that the question in its main point was considered as solved, and that until to-day it is described in all text-books in the same manner. Nor has the theory of inflammation of *Cohnheim*, from the year 1867, which ought in the first place to have influenced the pathology of the vitreous, especially as we have here to do with a tissue destitute of nerves and vessels, had, as it appears, any important influence upon the prevailing doctrine. Only *Iwanoff* has made experiments upon frogs with reference to the results of Cohnheim.

* V. Graefe's Archiv für Ophthal., Vol. VIII., p. 1.

† Virchow's Archiv, Vols. XVI. and XIX.

‡ Ueber das Gewebe und die Enntzündung des Menschlichen Glaskörpus. Leipzig, 1860.

He injected coloring material into the lymphatics, and found, after an artificially produced *hyalitis*, pus cells filled with molecules of the coloring matter. He concludes therefrom that the pus does not originate from the cells of the tissue but from the blood.*

Berlin† also, in his examinations on the passage of foreign bodies into the vitreous, has considered the doctrine of Cohnheim, and after he had refuted an hypothesis favorable to this doctrine, he has nevertheless at the conclusion pronounced the view that the cells of the vitreous and the hyaloid membrane participate in the production of pus. The most recent researches on this subject I take from a résumé in the Centralblatt für die Medicinischen Wissenschaften, 1869, No. 13, über die Abhandlung von G. A. *Blix*, *Studier öfver Glaskroppen Stockholm Medicinskt Arch.* IV., No. 4. The author describes, first, the normal condition of the vitreous, and finds that it has no structure and no other elements, but wandering uni- and multi-nucleated cells with amœboid motions; on irritation, which produce inflammation it is asserted that, as with the cornea, the immigration of the white blood-cells takes place from the vessels of the surrounding tissue.

The now almost universally prevailing acceptance of

* According to the latest observations of *Reitz*, in Vienna, who proved in a similar manner that molecules of coloring matter might be found in the cells and in the intercellular substance, the value of these experiments would be greatly diminished.

† V. Graefe's Arch. für Oph., Band XIV.

idiopathic hyalitis, as well as of the formation of pus corpuscles from the cells of the vitreous, is chiefly based upon the results of the experiments of C. O. Weber. These results were principally gained by experiments on animals. If we examine them somewhat closely we can hardly reach the conclusion which was formerly deduced therefrom. According to my view, at least, it only follows from them that in the vitreous inflammatory products may be found; whether they really are produced there, and furnished by the tissue of the vitreous itself, is another question. Can we, after having inflicted a large wound upon the eye and injected irritating substances, or squeezed out more or less of the vitreous, and thus injured the sclera, choroid, and retina to no small extent, form a conclusion from the resulting panophthalmitis as to the independent inflammatory reaction of the vitreous? The sympathy into which the other organs are thrown is too great to be thus disregarded. The researches of *Ritter* also are open to a similar objection; he arrives, however, at quite a different result, and, as it seems, simply for the reason that, according to his opinion, in the vitreous and retina elements are wanting from which pus corpuscles might be formed.

In the present state of the doctrine of inflammation the problem is to produce independently of the other organs an inflammation or suppuration of the vitreous, or to prove the inability of the vitreous to pass independently into suppuration. To this end I have made experiments on rabbits, by injecting different strongly irri-

tating substances into the vitreous. As is known, every tissue capable of inflammation reacts upon irritation from foreign bodies in a twofold manner, either producing inflammation resulting in suppuration, or becoming encapsulated by the outgrowth of connective tissue. The potency of the irritation plays of course a large part in determining the result; but even upon the slight irritation produced by placing the coagulated white of egg under the cuticle, the surrounding tissue reacts by the formation of a capsule of connective tissue, however thin it may be.

If, therefore, we should succeed in producing an inflammatory reaction by means of a foreign body placed in the middle of the vitreous, be it a suppuration or the formation of a capsule of connective tissue standing in no provable connection with the surrounding membrane, the possibility of inflammation of the vitreous would thus be proved. If, on the contrary, the foreign body produces no clearly demonstrable change, its capability of independent inflammation must be denied. The latter, negative, result would prove much more than the opposite, as against this the objection might still be made that the pus corpuscles had migrated thither along the canal of the wound from the vascular parts. It is just this latter circumstance which renders the determination of the question by experiments so difficult, and becomes the source of so many and such various deceptions. If it were possible to introduce a foreign body or other irritant into the vitreous, without any injury whatever to the surrounding membranes, the question could be decid-

ed forthwith; but as this cannot be done we must, above all, endeavor, first, that the foreign body may lie free in the midst of the vitreous; and second, that as little injury as possible may be done to the surrounding membranes.

Donders sought to attain these ends in a very ingenious manner, by drawing a thread of india-rubber through the eye, putting it upon the stretch, and then cutting off both ends at the same moment, so that the part lying between might shrink into the vitreous. In Zehender's Klinischen Monatsblättern, 1864, p. 323, we find the statement that around such bodies a circumscribed suppuration is formed, unconnected with the surrounding membrane; it is a pity that further communications concerning this point, and especially the appearances upon dissection, have not appeared.

The method I made use of was the following: An extremely sharp and fine canule of a Pravaz's syringe was charged with an irritating substance, introduced into the middle of the vitreous from the front, and then the contents pushed out with a fine wire. The length of the foreign body (piece of wire, glass tube, etc.) was on an average from 5–7 mm.

Care is to be taken in this operation that no wound of the posterior capsule, or the neighboring wall of the globe takes place, and that further, in withdrawing the foreign body from the vitreous itself, it should be slightly depressed. If this latter precaution is neglected, it not seldom happens that the foreign body, probably in consequence of the intra-ocular pressure, follows the di-

rection of the needle, and then either comes in contact with the wall of the bulb, or partially returns into the canal of the wound through the investing membranes; indeed it happened to me twice that it was forced directly out through the wound and buried itself under the conjunctiva of the bulb. Even in spite of these precautions it happens but too frequently that the foreign body, upon the withdrawal of the canule, or often, also, at the expiration of some time, from a sudden movement of the eye, changes from its original situation in the direction of the canal of puncture and comes in contact with the membrane surrounding the vitreous.

In order to observe ophthalmoscopically the reactions of the vitreous under strong irritants, as well as to control subsequently the microscopic section, I modified my experiments in the following manner: A small lymph tube was almost completely filled with croton oil, and in order that it might not be emptied during the introduction the upper end was stopped with wax; it was then put into the canule of a Pravaz's syringe and introduced into the vitreous in the manner described above. The latter would thus naturally be brought in contact with the croton oil in the under end of the tube, and the ensuing changes could be clearly observed with the ophthalmoscope. If the tube was not filled in its whole extent there would be found, immediately after its introduction, commonly a layer of air between the two fluids. This, however, was very soon absorbed, and did not hinder their direct contact. After the section, the

changes which had taken place in the tube could be examined with system 5 and 7 (Schieck and Son).

The entrance of the canule could naturally only take place either through the sclera, or, anteriorly, through the cornea. I made use of the first method in most of the experiments, and as the most convenient from above; the latter was accompanied with too many disadvantages in the wound of the cornea, the escape of the aqueous and lens matter, and the irritation of the ciliary body from puncture of the lens, not to interfere with the simplicity of the experiment, to which is to be added further, the impossibility of minute ophthalmoscopic observations. In only one case among many could I regard the experiment as a success.

It might be proposed previously to extract the lens, and after complete healing of the wound to introduce the foreign body through the cornea; but as I could not promise myself much from this method, I have, in consideration of the completeness of the results obtained by the other method, omitted to employ it.

In the following experiments I shall only bring forward the results of ophthalmoscopic and pathologico-anatomical examination. The general results which I deduce from them will follow. Before, however, I pass on to these. I regard it as necessary, first, to communicate the conclusions which I have arrived at from my experiments as to the normal structure of the vitreous, especially in rabbits. I may, I suppose, here omit the several differences of opinion of the most celebrated observ-

ers as to the structure of the vitreous. I refer on this subject to the treatise of Iwanoff (V. Graefe's Archiv, Band XI., 1).

My experiments induce me in the main to accede to the views of the investigator just mentioned. The correctness of the description of the several cell-forms, and the truthfulness of the illustrations, are, in my opinion, not to be disputed. I only know one point that I might modify, which is certainly not unimportant for the appreciation of the several elements. It concerns the division of the cells into three kinds, namely, round cells, without prolongations, furnished with one or two nuclei; stellate and spindle-shaped cells; and finally the so-called *physaliphorous* cells. My experiments lead me to the conclusion that these must be reduced to one cell-form, and that the one first described by *Iwanoff*.

These are the round contractile cells, with fine granular contents, which sometimes mark, to a certain degree, one or other of the (2–3) nuclei; in respect to their size, form, and action with reagents, they show so decided an identity with lymph-cells that I am as little able to point out any certain marks of distinction between these two forms as between the latter and the white corpuscles of the blood. *Iwanoff* calls them formative cells, and they deserve the name in so far that other cell-forms are developed from them. He himself describes this action, with regard to the second kind of cells mentioned by him, in the following words: "Such cells may be observed as a further development of the first form, and one

may mark among the round cells several with very short outgrowths." By direct observation I have succeeded now in seeing, especially in rabbits only a few days old, the various forms gradually developed from the round cells. This is best done by placing a quite fresh vitreous upon a warm stage. On examination we find, besides the round cells, some spindle and star shaped ones; others with long filiform processes, or with short clavate cells provided with pale-colored projections. If we observe now a round cell, we not seldom succeed in perceiving in the same, suddenly, a little cone-shaped projection consisting of a completely hyaline mass; the same increases either by bulging out, or becomes pointed, and then sends forth one or more processes. This may be developed in two or more spots, and then there arise, after some time, formations which cannot be distinguished from unipolar spindle or star shaped cells. The fine pale-colored processes often exceed ten times or more the length of the original cell; indeed it sometimes seems as if the processes of two neighboring cells had united together. In another instance again, we find a whole bundle of threads of varying length proceeding from the hyaline projection, on which sometimes a small vesicular formation is suddenly developed. If the original hyaline projection does not send out any processes it generally increases, and is then separated from the cell mass by a circular constriction. The above changes of form, which have not been described with perfect minuteness, have reference principally to the hyaline matter of

the cells; but the nuclear contents undergo, at the same time, by these changes a transition of form.

In some cases it is lengthened, in others pushed aside, and then usually appears somewhat more opaque. We have the opportunity of observing the latter sometimes, which happens usually in cells which send forth gradually a single globular hyaline mass, which often surpasses the original cell in size, so that the latter appears, at least the nucleus and the granular contents, as a smaller formation attached to it, and only separated by a circular constriction.

If the latter disappears more and more we obtain a globular formation, on the peripheric zone of which the granular matter, with nucleus, has been deposited like a crescent in shape.

The description, as well as the representation by figures in other places, as in the third kind of the so-called physaliphorous cells, have so great similarity to the cells just mentioned that I believe, especially as I could not find any other similar formations, that here exactly the same elements are found.

I could never convince myself of Iwanoff's conjecture, that the vesicle possessed a membrane of its own. The destination for the secretion of mucus of this membrane has, so far, not been proved by any fact. With regard to the following experiments, I remark, that the examination of the vitreous was always made while it was quite fresh, that of the surrounding tissues usually in a dried state, or after hardening in Müller's fluid.

R. and L. mean always, in the experiments, right and left eye. In referring to the morbid appearances, the ophthalmoscopic examination was relied upon in order to avoid too great length of description, but the relation of the other parts was always mentioned when anything appeared of interest in determining the question.

Experiment 1. *March* 31*st*, 1869. *Afternoon.*

A small gray rabbit; a wire was introduced into the vitreous of the left eye from above, which was free in the midst of the vitreous.

1st April. No change perceptible.

2d April. The lower end of the wire is surrounded by a regular white mass. Upon closer inspection it is found that the upper part also is surrounded by a translucent whitish cloudy matter, from which passes, in the direction of the track of the puncture, a whitish cord with opaque margins, towards the upper wall of the bulb.

3d April. The whitish cloudy matter around the foreign body, and also the cord-like projection above, have become somewhat denser and larger in circumference.

8th April. The whitish mass is larger, irregularly leaf-shaped; in the neighborhood some obscuration of the vitreous; the cord towards the upper part slightly pointed.

Section.—The vitreous is, with the exception of the spot where the puncture was made, completely separated from the other tissue. A whitish cord, becoming thicker by degrees, proceeds from the external wound, a little behind the ciliary body, downwards and forwards, in which the foreign body is embedded. The same shows some enlargement, and passes in the neighborhood of the lower margins of the lens into a thick, yellowish, white mass, which is connected to the ciliary body, at the lower part of the bulb, by a cloudy, slimy matter.

Around the same is found a delicate whitish striped tissue. The cord lies, for the most part, close to the posterior capsule of the lens; likewise the larger part of the thick whitish prominence.

The same is shown by the microscope to consist of fine fibres and very delicate tissue, interspersed with numerous contractile round cells.

The mucus, somewhat cloudy tough matter, which proceeds from the under part of the enlargement towards the ciliary body, contains the same fundamental tissue with contractile cells, and also a goodly number of round, finely granular accumulations of pigment. At the end of the cord towards the wound are found the same elements in a somewhat more distinct striated matrix.

Experiment 2. *March* 31*st*, 1869. *Afternoon.*

A wire was introduced from above into the right eye of a young white rabbit.

Ophthalmoscope.—The wire (even with the naked eye) is visible behind the lens in the substance of the vitreous. The following days no change was to be seen around the foreign body.

April 5th. *Section.*—The foreign body floating free in the vitreous without having produced any macroscopically perceptible change in it.

Experiment 3. *March* 27*th*, 1869. *Afternoon.*

A wire was introduced into the right eye of a large gray rabbit.

March 30th. The foreign body lies in the upper part of the vitreous. Its lower half is enveloped by a cloudy mass, from which a cloudy appearance proceeds in different directions into the vitreous. The upper half is surrounded by a whitish material, which cannot be followed to its termination.

April 1st. The whitish enlargement has grown somewhat in its lower part.

April 7th. The enlargement now entirely surrounds the foreign body.

April 21st. The margin of the enlargement appears somewhat irregular; the cloudiness has, on the whole, slightly increased.

May 3d. The cloudiness somewhat denser in a few spots only, otherwise in statu quo.

Section.—The bulb is opened from behind; in the upper part, on the ciliary portion of the retina, and adherent to the same, is a white plug in which the foreign body is enveloped. It is partially in contact with posterior capsule of the lens. The vitreous body shows, in its middle, round and oval cells, most of them with a very lively amœboid motion. In the situation of the cloudiness a very fine fibrous, here and there finely granular, tissue was perceptible, in which were found large spindle and star shaped, often, also, anastomosing cells. The whole has an appearance similar to embryonic connective tissue.

The separate cells contain one or more nuclei; around them is found a fine granular matter which extends into the projections of the cells. Besides there are present numerous round cells with amœboid motion, which, in their processes, become often deceptively similar to spindle and star shaped cells. In the part bordering on the white mass, the striped ground substance is somewhat more dense and the spindle-shaped cells are more numerous. The plug consists exclusively of pus. The tissue bordering on the canal of the wound is completely filled up with pus corpuscles.

Experiment 4. *April 24th*, 1869.

A needle was stuck into the vitreous of the left eye of a large gray rabbit, its upper end projected a little beyond the sclera.

April 26th. The upper part of the vitreous from the place of entrance of the needle to its centre, the surrounding tissue of the vitreous, are found traversed by a blackish finely granular cloudiness; the lower half of the needle is still shining, and the surrounding vitreous quite clear.

April 27th. The cloudiness has increased more below towards the point of the needle, so as almost to reach it.

April 28th The cloudiness has become somewhat denser and more extensive in the upper part; the lower end of the needle is yet free.

April 29th. Point still free.

May 2d. The cloudiness has now reached to the outer side of the point of the needle.

May 3d. The needle is now quite enveloped by the cloudiness.

Section.—The vitreous opened from below. The cloudiness around the needle consists of a fine striped basis matter, in which are embedded many contractile round cells and a dark granular matter.

The translucent cloudiness which envelops the needle below becomes more dense superiorly, the number of the contractile cells at the same time greater. At the point of entrance into the vitreous this matter is connected with the surrounding tissue, and consists exclusively of pus corpuscles.

Experiment 5. *March* 27*th*, 1869. *Afternoon.*

A wire was introduced into the left eye of a little gray rabbit.

March 30th. The foreign body lies in the upper part of the vitreous, only its lower end is visible, and is surrounded by a slight cloudiness, some trails of which proceed deeper into the vitreous.

March 31st. *Section.*—The wire attached to the upper wall of the bulb completely surrounded by purulent matter, which produced cloudiness of the vitreous as already described above.

Experiments 6 *and* 7. *March* 31*st*, 1869. *Afternoon.*

Pieces of wire were introduced into both eyes of a young white rabbit.

Ophthalmoscope.—The same were seen distinctly in the middle of the vitreous; the wire in the right eye had a direction from before backward.

April 1st. No cloudiness perceptible on either side.

April 2d. Same condition.

April 3d. Left eye: from the upper end of the foreign body extends superiorly a dark punctated finely fibrous stripe of the thickness of the foreign body. *Right* eye, no change.

April 6th. A blackish cloudiness like a spider's web has now formed

around the foreign body in the left eye. At the next examination the cloudiness of the left eye has only slightly increased, so that on the 30th of April it is about three times as large as the foreign body; the foreign body itself is still distinctly visible. Right eye, no trace of cloudiness perceptible.

Until the 25th May no other change appeared, except that the cloudiness around the wire in the left eye was no longer as regular but more flocculent in appearance. Right, no change.

May 28th. *Section of right bulb.*—Bulb opened posteriorly; the vitreous appears of normal consistence and is apparently quite clear; upon closer examination we find, however, that a slight mucoid cloudiness extends from the foreign body in the direction of the point of puncture.

One part of the substance of the vitreous, in which the foreign body as well as the cloudiness is situated, is taken out, and it is found that the latter consists of the most transparent finely extended, in many parts irregularly striated, matter, which is throughout interspersed with little points. In many spots striping as well as punctation reddish in color (probably from small particles of oxide of iron, which were introduced into the vitreous with the foreign body); cellular elements of any kind wanting.

Section, left bulb.—Round the foreign body is found a whitish cloudiness which sends a distinct prolongation towards the puncture. It consists of pretty dense, somewhat wavy fasciculi of fibres.

Upon the addition of acetic acid it became somewhat darker, and distinct spindle-shaped cells appeared; besides there are found alongside of the fasciculi of fibres, here and there, contractile round cells.

Experiment 8. *April 27th,* 1869. *Afternoon.*

A little piece of wire was introduced into the vitreous of a young white rabbit, through the cornea and lens, after the pupil had been dilated with atropine.

The aqueous humor emptied itself, and the pupil contracted. Upon

immediate examination it appeared as if the foreign body reached only partially into the vitreous—that, on the contrary, the larger part remained in the posterior part of the lens.

April 28th. Wound of cornea closed; pupil very narrow, irregular; iris strongly protruded forward, somewhat folded, much injected; pupillar region filled by a whitish material.

April 29th. The injection of the iris less.

April 30th. The pupil dilates only from above downward after the application of atropine, synechiæ right and left. The clouded, cone-shaped lens matter which has escaped from the capsule adheres with its point to the posterior wall of the cornea.

Section.—The posterior part of the bulb was removed; we then see that the foreign body is almost altogether in the lens; only a small part has perforated the posterior capsule and reached the vitreous.

From this point a cone-shaped cloudiness extends into the vitreous. Upon examination with a magnifying-glass, we find this to be composed only of drop-like, strongly refracting larger and smaller roundish elements.

The microscopic examination shows variously sized strongly refracting globules, and around and between the same a dark, finely granular, sometimes striated material. The existence of lymphoid corpuscles could not be discovered, neither here nor in the lens matter which surrounds the wire in its greater part.

Experiment 9. *April* 30*th*, 1869. *Afternoon.*

A little piece of wire was introduced into the left eye of a young white rabbit.

Ophthalmoscope.—We observed with some difficulty, after dilatation of the pupil, the lower part of the wire. As it might be surmised that, perhaps, the upper part had receded into the canal of the wound, or at least remained in contact with the upper wall of the bulb, a second wire was at the same time also introduced from above, and luckily into the lower part of the vitreous.

May 1st. The foreign body last introduced lies still free in the vitreous without any cloudiness whatever. Strong chemosis of the upper lid, iris very hyperæmic, great mydriasis.

May 2d. Chemosis less.

May 3d. The wire in the lower part of the vitreous still quite free from cloudiness; the one lying in the upper is more enveloped in a white dense mass.

May 6th. Only to-day a slight cloudiness has also appeared around the foreign body, hitherto free from it, which, as it seems, extends somewhat upwards.

Section.—The cornea and iris were cut away, and the lens removed. The vitreous appears of a soft consistence. The one piece of wire lies in the middle of the anterior part of the vitreous.

Around it is seen, beside some blackish points (impurities), cloudiness quite slight, and hardly recognizable. The same consists of contractile round cells, and of a sparse, fine fibrillated substance in which are found a good many distinct spindle-shaped cells with fine granular contents. Superiorly it passes directly into the whitish mass of pus which adheres to the upper wall of the bulb and encloses completely the other piece of wire. The tissue surrounding both wounds is completely filled with pus corpuscles.

Experiment 10. *April* 30*th*, 1869.

A little piece of wire was introduced from above into the right eye of a young white rabbit.

Ophthalmoscopy.—Only the lower part of the wire could be seen in the vitreous.

May 3d. With dilated pupil, we perceive to-day that the upper part of the foreign body is surrounded by a white material, the other part reaches free into the vitreous; somewhat posteriorly and inwardly there is a pointed elongation of the cloudiness extending into the vitreous.

May 4th. The white matter which proceeds from the foreign body in the upper part of the vitreous has become larger; a broad, some-

what translucent string extends from the same to the lower end of the foreign body; here is found a denser material, blackish or whitish according to the illumination, which again sends forth a slight, thready, punctated cloudiness into the vitreous.

May 5th. The white swelling in the upper part has grown a little.

May 6th. Status idem.

Section.—A white plug of matter proceeds from the upper wall of the bulb, almost completely enveloping the foreign body; from it extends beside the foreign body, even extending beyond it, a white cord with a moderate swelling at the lower part of the vitreous. The same consists of numerous round contractile cells, and a sparser substance, very pale, containing here and there spindle-shaped cells. In the neighborhood of the purulent deposit all the tissues are found to be interspersed with pus corpuscles.

Experiment 11. *April* 4*th*, 1869. *Morning.*

A lymph tube, nearly filled with croton oil, the upper end of which was closed with wax, was introduced from above into the right eye of a young white rabbit.

Ophthalmoscopy.—We see the little tube standing perpendicularly in the vitreous; the lower end has a dark appearance, with a bright stripe in the middle. During a rapid motion the tube rose upwards a little.

May 5th. The dark portion of the lower part of the tube has almost entirely disappeared; cloudiness is nowhere to be seen.

May 6th. From the upper portion of the vitreous cloudiness extends in different directions; the lower part of the tube is yet entirely free.

May 7th. The upper part of the foreign body is to-day enveloped by a white mass, from which proceeds a striated cloudiness along the tube into a white star-shaped mass, beyond which, however, is still visible the lower end of the tube.

May 8th. The cloudiness has increased.

Section.—The eye is opened from behind, the vitreous appears some-

what liquid, and traversed even in the apparently clear portions by circular contractile cells. The same elements, together with spindle-shaped cells, with fine granular contents, embedded in a very finely striated ground stroma, compose the filamentous cloudiness. The latter stands in direct connection with the mass of pus adhering to the upper wall of the bulb, and enclosing the larger part of the little tube. In the tube is found, at the point of contact between the croton oil and the substance of the vitreous, a dark matter, consisting of many round globules. Cellular formation of any kind could not be found in the little tube.

Experiment 12. *May* 4, 1869. *Forenoon.*

A little tube filled with croton oil, and open at both ends, was introduced from above into the left eye of a young white rabbit.

Ophthalmoscopy.—The tube lies transversely in the middle of the vitreous; at both ends blackish spots are seen.

May 5th. The blackish spots have disappeared. No other change perceptible in the vitreous.

May 6th. Very slight cloudiness in the vitreous, which extends from above to below, and ramifies extensively into the vitreous; it is connected to the foreign body only by the upper end. The remaining part is yet entirely free from cloudiness.

May 7th. The cloudiness has increased; and is densest in front of the foreign body.

May 8th. *Section.*—The bulb opened from above. Consistency of the vitreous normal. A very slight cloudiness extends from the puncture and its immediate neighborhood, towards the end of the tube; the lower part of the same is filled with a whitish cloudy mass, which is proved under the microscope to consist entirely of fine dark granules. Cloudiness in the vitreous shows principally the same character as has been already frequently described.

Experiments 13 *and* 14. *May 4th,* 1869. *Morning.*

A little lymph tube filled with croton oil was introduced from above into the vitreous of both eyes of a young white rabbit.

Ophthalmoscopy.—L. The little tube hangs with its upper end on the upper wall of the bulb; in the afternoon a bluish-white discoloration was visible. R. In the lower part of the vitreous are found two little glass tubes lying crosswise; their contents seem to be emptied out (the original tube was probably broken in the introduction).

May 5th. L. The upper part of the foreign body is enveloped in a cloudy whitish matter. The lower is entirely free in the vitreous. R. Both the foreign bodies lie deep in the vitreous, and have changed their position as compared with yesterday.

A little externally is found at the level of the retina and choroid an oval white spot, in whose vicinity is seen a moderate hyperæmia of the choroid, and some small extravasation of blood.

From the middle of this spot arises a coniform, slightly translucent punctated cloudiness, which passes both the foreign bodies which are lying in the entirely clear vitreous, and extends a little beyond its centre.

May, L. Status idem. R. Only the position of the foreign bodies has changed slightly.

May 7th. L. The cloudy white matter somewhat augmented; lower part of the little tube still free. R. The whitish spot is now, especially in its centre, clearly prominent, and there projects from it the cone-shaped cloudiness. The glass tubes are not connected with the cloudiness, and their ends may be clearly seen.

May 8th. L. Status idem. R. The cloudiness has slightly increased.

May 10th. L. The whole tube is now enveloped in a veil of cloudiness, which, proceeding from the white mass, extends far into the vitreous. R. Upon the prominence situated in middle of the white spot, which reaches somewhat into the vitreous, and where the conical cloudiness begins, there wind from above one, and from below two vascular branches, proceeding from the choroidal vessels. Around the tube not a trace of cloudiness.

May 11th. Both sides status idem.

May 12th. L. Status idem. R. The prominence in the middle of the white spot has decreased a little. Both tubes have again changed their relative position; one appears now to touch by its end the wall of the bulb.

May 24th. L. The cloudiness somewhat increased. R. The vessels have disappeared from the tumor; the latter itself, with the cloudiness proceeding from it, appears to have become a little thinner and denser. The little tubes have again changed their position, so that the lesser one now touches the cloudiness with its outer end; the larger one has attached to the part which already seemed to be in contact with the wall of the bulb, a distinctly conical white tumor, from which a light cloudiness extends over the whole tube. *Section of L.*—The eye opened from behind, exuding clear vitreous, containing a moderate number of round contractile cells. The tube is in contact with the upper wall of the bulb, where a dense cloudiness exists, growing gradually lighter below.

It consists of fine fibrillated lightly punctated matter, with spindle-shaped and numerous contractile round cells.

Section of R.—The bulb opened from before. The larger tube has on its outer end a whitish mass. The same lying in the immediate neighborhood of the ciliary body, yet a definite connection between the two is not macroscopically demonstrable. The part of the ciliary body with the white mass and tube were placed upon the stage, and it was found upon examination that the white mass consisted entirely of pus corpuscles, and that proceeding from the same there extended to the ciliary body a fine fibrillated tissue, containing many spindle-shaped and round cells; the ciliary body at the point of connection was interspersed with round cells. The whitish tumor and conical cloudiness exhibited the composition already frequently described.

Experiments 15 *and* 16.—*May* 9*th*, 1869.

A wire was introduced through the cornea and lens of the right eye of a medium-sized red rabbit. Aqueous humor flowed out.

L. A little tube filled with croton oil, stopped at one end with wax, was introduced into vitreous from above. At the immediate ophthalmoscopic examination it could be seen in the upper part of the vitreous.

May 16th. R. Anterior chamber bulged out; lens matter exuded, and consolidated with the iris and cornea. L. The tube is only distinctly visible at its lower part; the upper enveloped in cloudiness.

May 11th. R. Lens matter very much swollen. L. The tube is no longer to be discovered.

Section of R.—Bulb opened from behind; the cloudiness in the vitreous is most dense behind the periphery of the lens, and there in direct connection with the ciliary body. It consists of fine fibrillated stroma, with preponderating contractile round cells, and a few spindle-shaped cells. The greater part of the lens is clouded and somewhat swollen; in the same the foreign body is stuck fast.

The lens fibres are a little separated at the clouded portion, and numerous large and small globules exude therefrom.

The matter lying round the foreign body consists of entirely disorganized lens fibres, with here and there embedded nuclei and granules.

Section of L.—(The bulb opened anteriorly.) The foreign body lies transversely in front of the wound of the upper wall of the bulb, and is attached to it by a whitish membrane, from which slight cloudiness extends into the vitreous.

The examination of the tube shows that its contents consist of dark, finely granular, strongly refracting matter.

Experiment 17. *May* 11*th*, 1869.

A tube filled with a strong solution of nitrate of silver was introduced from above into the right eye of a large black and white rabbit.

Ophthalmoscopy.—The tube lies in the middle of the vitreous, close behind the lens.

May 12th. A considerable cloudiness extends from above to the foreign body, which continues beyond the immediate neighborhood of

the tube, and is greatest especially in the lower part and round the tube itself.

May 26th. The vitreous appears to be filled with a whitish matter. Bulb very soft.

May 27th. *Section.*—The vitreous is almost entirely filled with pus. The foreign body lies behind the lens. From the puncture extends a pretty thick cord-like mass to the centre of the purulent deposit, consisting of a dense striated material with spindle and star shaped cells, and is traversed by numerous vessels. Contractile cells and granular masses distributed in great number through this tissue.

Experiment 18.

A little lymph tube, filled with croton oil and tapped at one end, was introduced from the side into the left eye of a black and white rabbit, May 26th, 1869, in the morning.

The immediate ophthalmoscopic examination showed the tube lying obliquely in the vitreous, and that the posterior capsule had been injured in its introduction.

In the afternoon, strong chemosis.

May 27th. A circumscribed whitish cloudiness, which seemed to be attached to the foreign body, in the posterior part of the lens.

Section.—Bulb opened from behind. The vitreous is traversed in different directions by fine whitish membranous opacities, all in direct connection with the wound and the neighboring part of the ciliary body. The same are found strongest directly around the foreign body, which hangs free in the vitreous, and is attached at one end to the posterior surface of the lens. The microscopic examination shows a fine striated matter, in many places sown with very fine granulations, and here and there little accumulations like pigmentary granules. Lymphoid corpuscles are only sparsely seen. The little tube was brought under the microscope, and it was found that the croton oil was in direct contact with the vitreous, in which nothing was found but round globules and granules.

Experiments 19 *and* 20. *May* 11*th*, 1869. *Morning.*

Into the left and right eyes of a gray rabbit, air was introduced by means of a Pravatz' syringe.

Ophthalmoscopy.—L. In the upper part blackish hemispherical prominences; cloudiness of the vitreous. R. Above a dark hemispherical mass; no cloudiness.

May 12th. L. A great deal of dark flaky cloudiness floating in the vitreous. R. Only a single large flake. L. The flakes a little more dense, and by their side a fine punctation is seen which extends through the whole vitreous. R. The flake has entirely disappeared, therefore air is again injected. Besides two air-bubbles attached to the upper wall of the bulb, a smaller one is observed in the middle of the vitreous, which has the appearance of a disk with a broad dark peripheric zone, and a bright centre, through which is seen the red background of the eye shining through.

Section of L. in the afternoon. Upon cutting the vitreous a dirty reddish fluid flowed out; this discoloration came from extravasation of blood numerously disseminated through the vitreous; the latter were mostly surrounded by white cloudiness, extending in different directions, especially, however, towards the region of the wound, to be in direct connection with the enveloping membrane. The whitish cloudiness consisted mostly of accumulations of very variously shaped lymph corpuscles, which were sometimes strewn with little dark granules; the majority, however, were filled with dirty yellowish or brownish red contents. Many of the round cells showed still a distinct amœboid motion, and once I could observe how the processes produced thereby extended themselves to a neighboring blood corpuscle, as they spread more and more over it; the latter at last was completely enveloped, and in this manner as it were included.

I found, likewise, in other places distinct roundish cells containing blood corpuscles.

Section of R.—Bulb opened from behind; in the vitreous was found widely diffused cloudiness, which in some places enclosed air. One part of the same, with an air-bubble, was examined microscopically,

and an extremely fine punctated and striated matter was found, which was most distinctly developed in the immediate neighborhood of the air-bubble. Roundish cells were only very sparingly perceived. In the neighborhood of the puncture a little extravasation of blood, showing a similar relation to that described in the preceding dissection.

Experiment 21.

On the 11th of May, 1869, a little piece of wire was introduced into the vitreous of a small black and white rabbit, from below, and thereby the posterior capsule somewhat injured.

May 13th. Some slightly turbid lens matter has exuded.

Section.—The foreign body sticks partly in the lens. Cloudiness extends from the wound towards the part of the foreign body which extends into the vitreous; it consists entirely of roundish cells with an amœboid motion. They contain nuclei, together with dark, strongly refracting granules, which frequently obscure the nuclei.

The cloudiness directly adjoining the posterior capsular wound consists only of disintegrated lens matter, with larger and smaller hyaline globules.

Experiment 22. *May* 26*th*, 1869. *Morning.*

A little glass tube containing croton oil, and closed at the top with wax, was introduced from the outer side into the vitreous of R. of a large white rabbit.

Ophthalmoscopy.—The lower end of the tube reaches free into the vitreous; the other is not visible. The vitreous is as yet separated from the croton oil by a column of air contained in the tube. In the afternoon a whitish discoloration is perceptible around the wound of puncture, and at the same time a diminution of the column of air.

May 27th. A light cone-shaped cloudiness surrounds the tube from its outer portion to its middle. The other end is free in the vitreous. Upon motion of the eye distinct ballottement of the foreign body.

Afternoon. The vitreous is now in direct contact with the croton oil,

as in the middle of the originally empty part of the tube only a little bubble of air is to be found.

May 28th. Air completely disappeared; cloudiness increased, and extends, as a very fine granular appearance, beyond the foreign body deeply into the vitreous.

Section.—Consistency of vitreous good. The lymph tube sticks partly in the canal of the wound of the surrounding membranes, and is surrounded by a whitish cloudiness which extends far into the vitreous. The latter consists of a fine striated material, with numerous lymphoid corpuscles with amœboid motion. In the tube itself croton oil is in contact with the vitreous, and a somewhat dark finely granular matter like an emulsion is here found. Cell elements are nowhere discoverable in it.

Experiment 23. *May* 30*th*, 1869. *Morning.*

A lymph tube, filled with croton oil, closed at one end, was introduced into R. from above, through the sclera, into the vitreous of a large gray rabbit.

Ophthalmoscopy.—It lies nearly in a vertical direction in the lower half of the vitreous; the latter is yet separated from the croton oil by a small layer of air in the tube. The posterior capsule was injured by the puncture. At 4 o'clock P.M. the air layer had decreased more than one-half.

May 31st. Morning. Layer of air has completely disappeared. Cloudiness in the vitreous has not been observed till now. At the point of contact between the croton oil and the substance of the vitreous a small zone of whitish appearance is found.

June 1st. Cloudiness of the posterior part of the lens, and in the vitreous.

Section.—Bulb opened from behind. From the puncture extends a cloudiness, growing denser and broader below, which continues to the pupil and passes over into the vitreous. It appears to be greatest on the upper part of the tube. The latter was taken out together with the surrounding vitreous. The cloudiness consisted of a great

mass of contractile cells of very varying forms, beween which were found in many places a very finely striated material. In the tube itself was found, at the point of contact between the vitreous and croton oil, and extending into the latter, a dark matter containing little highly refracting globules.

Experiment 24. *May* 31*st*, 1869. *Afternoon.*

Air was introduced by means of a Pravaz' syringe into the vitreous of R. of a gray rabbit. The air can be seen by the ophthalmoscope at different points.

June 1st. Air-bubles have disappeared, with the exception of a small one in the middle of the vitreous; distinct filamentous and membranous cloudiness.

Section.—From the canal of puncture cloudiness extends in different directions through the whole vitreous. It consists of numerous lymphoid elements, and finely striated matter disseminated everywhere, which shows in many spots a distinctly membranous layer with very fine points.

Experiment 25. *June* 2*d*, 1869.

The canule of a Pravaz' syringe was introduced into the vitreous of a large gray rabbit, and the same divided in several directions. The immediate examination showed no change.

June 3d. Slight cloudiness traverses the vitreous in different directions.

June 4th. This is to-day more distinct, and near the middle of the vitreous two denser and knob-shaped swellings are to be distinguished.

June 5th. Cloudiness still on the increase.

June 6th, *Section.*—Bulb opened from behind. A slight cloudiness proceeds from the puncture, which passes almost completely through the vitreous. In the same are marked especially two cords, which towards the middle of the vitreous terminate in two whitish swellings, from which again some slighter cloudiness proceeds. Embryonic connective

tissue, besides a large number of contractile round cells, form the principal part of this cloudiness. The tissue around the wound, which is situated near the ora serrata, is completely filled with lymphoid corpuscles.

Experiment 26. *June* 9*th*, 1869.

A little piece of wire was introduced from above into the vitreous of a little white rabbit. It lay, at first, in the middle of the vitreous, but rose afterwards, upon a sudden motion, to the upper part.

June 10th. The upper end of the wire passes into a whitish matter situated in the periphery of the fundus of the eye; here the wire is a little concealed; the other end reaches quite free into the vitreous. From the white point extends a dark, finely punctated, thread-like cloudiness, at some distance from the wire, to the middle of the vitreous, and spreads out into an irregular triangular mass which, upon motion of the eye, floats slightly.

June 11th. The white spot in the periphery has increased; quite a light-pointed cloudiness now extends from it over the whole length of the foreign body, while the cloudiness in the middle of the vitreous has increased considerably in density.

Section.—The foreign body adheres to the upper wall of the bulb, and is there, to about one-half, surrounded by a whitish mass of pus. The other half is free in the vitreous. Beside and a little in front of the same, proceeds, from above downwards, a thick cloudiness beyond the middle of the vitreous. The same contains very fine striated material with contractile round cells. At one spot there was found a very great multitude of cells similar to the so-called physaliphorous cells.

Experiment 27.

A little tube, filled with croton oil and stopped at one end with wax, was introduced into the vitreous of the left eye of a little white rabbit.

June 9th, 1869. The posterior capsule was slightly injured.

June 10th. Posterior part of the lens already somewhat clouded, so that the changes in the vitreous could not be observed with certainty.

June 11th. Status idem.

June 12th. Cloudiness increased.

Section.—The bulb opened from behind. From the point of puncture proceeds a membraniform cloudiness to the posterior capsule of the lens, which consist of a fibrillated substance filled with numerous, here and there oval, mostly, however, spindle-shaped cells, around which is situated a large number of contractile cells. The spindle-shaped cells have mostly a nucleus which becomes more distinct upon the addition of acetic acid, and assumes an irregular shape, and often appears to consist of many corpuscles united together.

The foreign body is most of it in the lens, which appears completely clouded in its posterior part. In the interior of the lens is found a whitish material consisting of very fine dark granules intermixed with oil globules; cellular tissue not discoverable. The ciliary process near the external wound is very hyperæmic, and its tissue completely filled with lymphoid corpuscles.

Experiment 28.

A little piece of wire was introduced from above into the vitreous of the right eye of a little white rabbit.

June 9th, 1869. Forenoon. The same lay in the upper part of the vitreous; not far from it a little air-bubble is seen.

June 10th. The foreign body has changed its position so that only its lower end is visible in the upper part of the fundus of the eye. Slight punctated cloudiness in different parts of vitreous.

June 11th. More diffused cloudiness to-day, with denser filaments, which extend from the foreign body to the middle of the vitreous.

June 12th. Status idem.

Section.—Bulb opened from behind. The greater part of the wire is enveloped in a mass of pus, which is attached to the upper wall of the bulb. From this point cloudiness extends into the vitreous, which consists of contractile round cells and a finely striated stroma.

In the denser filamentous cloudiness are found distinct bundles of embryonic connective tissue with spindle-shaped cells, and around the same all the transitional cell formation to the contractile elements. The tissue around the wound is dense and contains lymphoid cells.

Experiment 29. *June 9th,* 1869.

Air was forced into the vitreous of the left eye of a large gray rabbit, and the vitreous, by the introduction, was lacerated in several directions.

June 10th. Dark, pretty thick cloudiness moving upon any pressure upon the eye.

June 13th. Status idem.

June 14th. Cloudiness somewhat diminished.

June 17th. Again slight diminution of cloudiness.

Section.—Bulb opened from behind. Very fluid, apparently clear vitreous exudes, in which are found, in addition to some red blood corpuscles, contractile round cells in moderate numbers. Sometimes I succeeded in finding one or two red blood corpuscles in the midst of a variously shaped contractile cell. A thread-like cloudiness with some branches proceeds from the wound and extends beyond the middle of the vitreous; in one place it appears of a slightly yellowish red color. Upon microscopic examination it was found that the cloudiness consists of embryonic connective tissue, which is surrounded by contractile elements of varying forms; many of them have very fine reddish brown contents. A large mass of contractile cells is found on the somewhat yellowish red spot, which are mostly of roundish form, and are furnished with finely granular contents, varying in color from yellow to brownish red.

Experiment 30.

Two small lymph tubes filled with nitrate of silver in substance were introduced into the right eye of a large gray rabbit.

June 10th, 1869, in the forenoon. Immediately after the introduction a dense whitish cloudiness formed around one end of the tubes.

At first both lay in the middle of the vitreous; at 12 o'clock, however, they had risen, and there was seen now at the end of each a whitish mass which appeared sharply defined toward the vitreous. In the afternoon the tubes had risen still higher, so that their upper ends were no longer visible.

June 11th. Nothing abnormal to be discovered upon the external part of the eye, except a moderate redness around the wound of the sclera, such as is usually observed after puncture with a needle. Iris reacts well.

Ophthalmoscopy.—The tubes lie still in the upper part of the vitreous; the white lumpy mass on their ends is yet well defined against the clear surrounding vitreous. The more horizontal foreign bodies are in contact with their lower ends, and from this point extends a whitish somewhat striated thread in an upward direction. No other changes could be observed, either externally or by the ophthalmoscope, until the 17th of June.

June 17th. *Section.*—Bulb opened from behind. Perfectly clear vitreous flows out, in which no contractile cells are found. Both the tubes are lying in the upper part of the vitreous, and are joined to one another at their lower ends, and to the posterior capsule of the lens, by a whitish mass; they diverge toward their upper ends, and are there surrounded by a whitish nodulated cloudiness. A white striated filamentous cloudiness proceeds from the wound and passes directly to the point of connection of the tubes, which sends forth in the direction of each of them some further filaments of cloudiness. The whole is removed with the surrounding vitreous. The white color of the cloudiness changes immediately to reddish brown and then to black. Upon microscopic examination it is found that the thicker masses consist of a compact dark mass, appearing finely granular upon its margins, around which, as well as around the tubes themselves, a zone of contractile elements is found, most of them with fine dark granular contents. Besides these the surroundings of these masses were thickly strewn with little blackish points, which gave the impression, on any slight motion of the liquid, of floating upon an invisible membrane. The thread pro-

ceeding from the wound consists of fine fibrous tissue strewn with spindle-shaped cells and contractile round cells, changing into the greatest variety of forms.

Experiment 31. *June* 11*th*, 1869, 11 *o'clock* A.M.

A small lymph tube, partially filled with croton oil, and stopped at its upper end with wax, was introduced into the vitreous of a young white rabbit.

Upon ophthalmoscopic examination it could be distinctly seen in the middle of the vitreous. A small column of air in the tube intervened between the croton oil and the substance of the vitreous. At 4 P.M. the column of air had already diminished one-half.

June 12th. Morning. The vitreous is now in contact with the croton oil; at the point of contact there is a light punctiform cloudiness, which extends somewhat into the croton oil. In the vitreous itself there is not a trace of cloudiness to be distinguished.

June 13th. The cloudiness extending from the point of contact of the two fluids into the croton oil has become thicker. Vitreous itself still entirely clear.

June 14th. To-day also there is no cloudiness discoverable in the vitreous upon the most careful examination. In the tube itself the croton oil has assumed a darkish color.

Section.—The bulb was opened from behind; completely clear vitreous, without even the least microscopic change, flowed out. The tube lay completely free in the vitreous; around the same completely clear vitreous matter was found with the naked eye, and with the strongest magnifying-glass no trace of cloudiness could be observed even in the puncture leading to the foreign body. In the tube itself there was a cloudiness extending throughout almost the entire mass of the croton oil, which was strongest at the point of contact; the substance of the vitreous in the tube was clear. The tube, together with the surrounding vitreous, and the tissue immediately around the puncture, was placed under the microscope and examined. This showed that the vitreous was entirely normal; only reaching from the puncture toward

the foreign body, but not extending quite to it, was found a strip consisting of a row of contractile round cells, lying side by side, in number from six to eight. This clouding in the tube itself consisted mainly of larger and smaller fat globules. The vitreous in the same was completely clear.

Experiment 32. *June* 23*d*, 1869.

A puncture was made into the vitreous of the left eye of a black and white rabbit, through the sclera, from above, with a discission needle. Up to the 26th of June no change in the vitreous was perceptible with the ophthalmoscope.

Section on that day. Bulb opened from behind; perfectly clear vitreous flowed out, and not the slightest cloudiness was to be seen even in the neighborhood of the puncture. The vitreous lying nearest the track of puncture was removed and placed under the microscope, and showed a train of extremely fine light fibres with undulating outline, in which were embedded both round and spindle-shaped and stellate cells, many of which had long processes. The cell contents were pale granular, and in some, on the contrary, black granular.

From the general review of these experiments it follows with great uniformity that nearly always, as the result of traumatic impressions, anatomical, and generally also ophthalmoscopically demonstrable cloudings of the vitreous have developed themselves. The same showed all degrees, from the densest masses to the finest mist-like appearances. The course of the process, and with it the development of the cloudiness, could be traced in almost all cases by means of the ophthalmoscope, and a gradual progression of the same from the puncture in the enveloping membranes towards the centre of the vitreous. Although sometimes the cloudiness was denser or at least more striking around the foreign body, upon

close examination a connection, mostly filiform, could always be perceived with the wall of the bulb. In some cases the cloudiness spread before or laterally from the foreign body deeper into the vitreous, leaving the portion directly around the latter for some time clear and translucent. (Experiments 10 and 26.) Experiment 14 gave an excellent opportunity of observing this relation of the cloudiness opposite to the part of the vitreous occupied by the foreign body in a very striking manner. Here, during the operation either by the canule or the foreign body itself, the wall of the bulb lying opposite the puncture was probably injured; in short, a whitish knot formed in it, sending distinct conical cloudiness into the vitreous; beside the same floated the two glass tubes, whose surroundings appeared nowhere clouded in the slightest degree. The same threw a distinct shade upon the fundus of the eye. Pretty soon vessels from the choroid commenced to be developed upon the surface of the swelling, and extended toward the vitreous. Hereupon followed a diminution of the swelling and a decrease in the density of the cloudiness. All this happened while the foreign bodies were floating in the perfectly clear vitreous, and were constantly changing their situation. This was observed for eight days. At last one of the tubes came in contact with the wall of the bulb, and a thick white cloudiness developed itself immediately at the point of contact.

The foregoing results, mostly obtained by means of the ophthalmoscopic examination, have been carefully proved

by the dissections of the bulbs, which were made in every instance, and the same results were always obtained, that in all cases a connection of apparently the most isolated cloudiness with the point of injury could be demonstrated. Let us turn to the results furnished by the microscopic examinations of the vitreous, together with the cloudiness it contained. In the greater number of cases there could be no doubt that we had to do with products which depended for their existence upon an inflammatory process. The whitish yellow masses, filling in some cases a large part of the vitreous, and in others hanging as small masses to the wall of the bulb, and usually enclosing the foreign body, were always found to be purulent in their nature. The filamentous and membranous cloudiness proceeding from the puncture showed many diversities one from another; this depended partly upon their density, and still more upon the length of their duration. Contractile round cells, with fine granular, often strongly refractive contents, which upon addition of acetic acid showed distinctly one or more frequently constricted nuclei, besides very finely punctated fibres visible only at a few points, were the only appearances noticed in the bulbs earliest examined. The changes of form which resulted from the amœboic motion are so various that it would be very difficult to give an adequate description of them. They very frequently represent the star and spindle shaped form, offering the greatest similarity to the cells of early connective tissue. Judging from preparations which I have taken from

cloudiness of longer standing, there is really no difference between these forms, and thus it is proved that also in the vitreous connective tissue is directly formed from these cells. In this cloudiness is found a fine fibrillated pale undulating tissue, interspersed with star and spindle shaped elements which are sometimes quite pale, in other cases provided with fine granular contents. They frequently send forth considerable prolongations, sometimes giving the impression that the so-called matrix was entirely composed of them. The fibres are usually sharply defined, and here and there arranged in bundles. In the immediate neighborhood of this tissue a great number of round cells, with their changeable forms produced by the amœboid motion, is usually found. In many preparations the transition of the separate formations may be found side by side. (Exp. 28.) If the cloudiness had existed a longer time the lymphoid elements were found only sparingly, and a dense, finely striated, wavy tissue, with spindle-shaped cells, with nuclei distinctly perceptible upon the addition of acetic acid, were found. (Exp. 6.)

These results of microscopic examination confirm likewise the already well-known fact, that connective tissue may, in the vitreous, be formed from the contractile elements, and that, in this manner, the so-called scar formation of the vitreous takes place. There arises now the more important question as to the origin of the lymphoid elements. The same may be found, of course, either in the vitreous itself or in the surrounding tissues. The recent doctrine of inflammation, defended by the fol-

lowers of Cohnheim, is confirmed by the vast majority of my experiments. The connection of the cloudiness with the enveloping membranes, especially in the track of the puncture, could always be anatomically proved; in Exp. 31 there was not, even after three days, the least trace of cloudiness around the lymph tube filled with croton oil, whilst from the point of injury a microscopically perceptible row of pus corpuscles extended towards the upper end of the foreign body, without, however, reaching quite to it. The tissues around the wound showed themselves, in all the cases examined, to be thickly strewn with lymphoid corpuscles. Adding to this the results in regard to the development and increase of the cloudiness obtained by ophthalmoscopic examination, as well as their special relation to the foreign body, results which have been already minutely described, all these facts must lead us to the conclusion that the inflammatory products deposited in the vitreous were formed by the surrounding tissues; indeed they are calculated to make doubtful the capacity of the vitreous for independent inflammation. I may here just refer to the relation of the tubes in the vitreous described in Exp. 14. I will, however, not consider this result yet as proving the latter view.

The objection might be raised here, that a certain inactivity of reaction upon irritation may be inherent to the organ; that impressions made use of were not violent enough, or were not long continued enough; that the capacity for inflammation would diminish with the dis-

tance from the vascular parts, and still other objections might be made. Upon more minute examination of Exps. 7 and 8, this question assumes another form. In both these cases cloudiness was found whose origin was, however, by no means the result of any inflammatory process whatever, as the microscopic examination showed. In the first case the cloudiness consisted exclusively of escaped large or smaller hyaline lens globules, together with ruptured clouded lens fibres, which showed on their external ends a finer striped arrangement. Collections of contractile or other cells could not be demonstrated. In the other case nothing but a more laminated granular, here and there striated, cloudiness was found in the apparently clear vitreous after the operation of the presence of a little piece of wire for fifty-eight days. I do not hesitate to ascribe the same to a chemical influence, as well as to the influence of air which was mechanically introduced along with the foreign body, and consider it, therefore, as a mere product of coagulation.

The difficulty of distinguishing between the latter and fibres of connective tissue is great; indeed in many cases impossible, when both appear together; the complete absence of cellular elements of any kind, and further the circumstance that the most careful daily ophthalmoscopic examination has never shown any cloudiness, as it would have done at the highest point of inflammation; the similarity, moreover, of this formation to those which the cloudiness around air-bubbles produced, proves here that the cloudiness in question must be considered the

result of coagulation. Although these experiments, in connection with the observations communicated above, fully prove that the vitreous does not react, that is, that the accumulation of lymphoid corpuscles is not occasioned at the point of greatest irritation, in our cases around the foreign body, which in every organ capable of inflammation will produce suppuration, or the formation of a capsule of connective tissue, I would not omit to confirm my view by other experiments in which stronger means of irritation were employed, and in which the point of contact of the same with the matter of the vitreous was examined immediately with the ophthalmoscope, and later with the microscope.

This idea led to experiments which I made with the lymph tubes filled with croton oil or nitrate of silver. The ophthalmoscopic changes appearing directly after the introduction of such irritants were, on the whole, very unimportant.

If the tube was closed at its upper end, and not quite filled with the croton oil, the column of air remaining in it showed itself by its dark outline with a brighter stripe in the middle. The resorption of the same followed rapidly often after twelve, mostly after twenty-four hours. Already, during the observation of this process, cloudiness proceeding from the puncture, and extending gradually towards the foreign body, was perceptible in the majority of cases, even if the tube was lying quite free in the vitreous.

In one case, however, no trace of cloudiness was dis-

coverable during the observations of three days (Exp. 31). But here, as well as in all other cases, distinct changes appeared in the tube at the point of contact of the croton oil and the substance of the vitreous. This was very beautifully observed, for at least two days, in Exp. 31. Soon after the disappearance of the column of air, appeared at the point of contact a dark rim in the croton oil, which increased during the next twenty-four hours and became stronger, and spread with diminishing density over the whole mass of croton oil. During this process, the part filled with vitreous remained perfectly clear. After section the above described change was shown, in a strong direct light, as a whitish dense cloudiness traversing almost the whole of the croton oil. The microscopic examination of the tube and surrounding vitreous proves the same to be an emulsion-like mass filled with greater and smaller refracting oil globules and dark granular bodies. The vitreous contained in the tube was always perfectly clear and free from cellular elements; even in those cases where the cloudiness had extended from above beyond the foreign body into the vitreous, if the same is thickly strewn with lymphoid elements, they will also find entrance into the tube itself. I have convinced myself of this by an experiment in which, after the introduction of a tube, by a wire drawn through the developing membranes, I have produced a rapid collection of pus in the vitreous.

In all the experiments mentioned above, the process of clouding was minutely followed with the ophthalmo-

scope, and as soon as it had passed a little beyond the lower end of the foreign body, the dissection was made. The effect of nitrate of silver in substance enclosed in minute glass tubes was only chemical, that is, the formation of silver albuminates, phenomena of irritation depending upon it, were not observed (Exp. 30). By the fact that in the tube itself, at the point of contact between the croton oil and the substance of the vitreous, no lymphoid corpuscles appeared, proof was obtained that the vitreous is not capable of forming pus corpuscles from the forming elements it contains, by the influence of strong irritation. Still further, it is a known fact, that in every organ which we consider capable of inflammation the accumulation of pus corpuscles appears greatest where the irritation is greatest. If we are willing to ascribe to the vitreous an independent power of reaction, that portion which has entered the tube cannot certainly be considered dead; there is not a single reason for such an idea. It is known, on the contrary, that the cellular elements which principally condition the power of life, retain their vitality very easily in such tubes, even outside of the organism. Why, I ask, do we not see any phenomena of inflammation appearing at the point of contact? Why does not the vitreous, if itself not capable of producing pus corpuscles, cause, by some reaction, the surrounding tissues to transfer their lymphoid cells to the point of greatest irritation, as is the case with the cornea (according to Cohnheim)? Why do we see, upon the influence of strongest

irritation, no greater reaction appear than is the case after a simple puncture with a needle? (Compare Exps. 31 and 32.) Why is there not least change in the relation of the vessels of the fundus of the eye after the introduction of nitrate of silver or croton oil? If we add to the conclusions the fact already mentioned, that a piece of wire in the vitreous has not produced any inflammatory phenomena for fifty-eight days; further, the observations which we have frequently made, that the cloudiness does not correspond to the irritation in the vitreous, but may extend in quite a different direction, I think that we may draw the following conclusions from these experiments:—

1*st. That in the vitreous, the gelatinous material, as well as the elements contained in it, be they of what kind they may, are not capable of inflammation from irritating causes sufficient to produce it elsewhere, nor of forming lymphoid corpuscles by morphological changes.*

From this follows—

2*d. That these must immigrate from the surrounding tissues;*

3*d. That the vitreous remains apparently quite passive, even under very strong irritation, or, more precisely, that it is not caused by the same to produce an accumulation of lymphoid corpuscles at the point of irritation, a phenomenon which in a short time follows similar irritation in organs susceptible of inflammation;*

4*th. That, therefore, the vitreous cannot be said to be susceptible of inflammation in the same sense in which we*

use that phrase of other organs, but that every so-called inflammation of it is to be considered as a secondary state depending on the changes in surrounding tissues.

An irritation in the vitreous will therefore only lead to phenomena of inflammation when it exerts an inflammatory influence upon the vascular tissues surrounding that body, and by bringing these into a state of actual inflammation. The products (or exudates) which are developed in consequence of such process are those which traverse the vitreous without regard to the nature of the irritation, and are capable of a further development, *i.e.*, the formation of new tissue resembling ordinary connective tissue; under different circumstances they deposit themselves as purulent accumulations, or are the subject of a retrograde metamorphosis. If it is asked how it is to be explained that the cloudiness usually extends in a regular direction towards the foreign body, and is located especially around it, I believe that it may be explained as follows:—Into the wound inflicted upon the surrounding membranes some particles of the vitreous are always forced by the intraocular pressure; the irritation of the wound produces an accumulation of lymphoid cells which are then brought in contact with the vitreous, and get in large numbers into its substance through the canal of the wound. As proof of this assertion, I refer to the experiments in which a dense cloudiness passed by the foreign body into the vitreous. I had taken the precaution in several experiments to remove the foreign body in the vitreous

from the canal of wound, in order not to produce a simultaneous rising of the same in removing the canule. By this means I had, as it were, made a new passage, and the corpuscles necessarily followed this passage principally. The less disturbed and the more rapid the healing of the wound in the surrounding membranes, the less the products of inflammation which find their way into the vitreous; indeed, under favorable circumstances, they may be wanting altogether, or at least be so insignificant that they escape the most careful ophthalmoscopic and microscopic examination.

II.

CONTRIBUTION TO THE KNOWLEDGE OF OPACITIES OF THE VITREOUS.

As I have had many opportunities during the experiments described to observe ophthalmoscopically the various kinds of clouding of the vitreous, as well as later to examine them microscopically, I will not omit to communicate briefly their results.

Considered from a pathologico-anatomical stand-point, I was compelled to distinguish three perfectly distinct varieties of obscuration of the vitreous.

1st. Such as must be considered as the product of any inflammatory process in the surrounding membranes.

2d. Such as have arisen from an intra-ocular hemorrhage; and,

3d. Such as have been produced by the influence of air or a chemical change.

It is natural that we cannot distinguish in every case any one of these causes alone; on the contrary, we frequently see two, or all three, represented. The cloudiness belonging to the first category shows all degrees of intensity, from contractile cells, only visible under the microscope, generally disposed side by side in a row, as we have seen in Exp. 31, to the denser accumulation of pus, or most pronounced accumulation of cellular tissue. The separate appearances have been mentioned with sufficient minuteness, so that it is unnecessary to refer to them again here. The opacity produced by the accumulation of fat globules may be considered as metamorphosed products of inflammation. I come now to the description of the second variety of opacity. To V. Graefe the credit is due of having first referred to this relatively frequent cause in man; compare his Arch., Vol. I., p. 1. He describes there minutely the ophthalmoscopic relation directly after the appearance as well as during the resorption of the opacities in question. He mentions further, that the duration of the latter has usually been from three to six weeks, several times even some months. These facts received universal confirmation, but the mode of resorption remained still uncertain, and there exists, as far as I know, in the literature of the subject no authoritative experiments on this point. My experiments with rabbits, in which I had opportunity of examining the varying stages of blood extravasations in

the vitreous, as well as two prominent cases in human subjects, seem to me to throw some light on this process. I was led by Langhans's experiments on the absorption of blood extravasations, which he made on rabbits, guinea-pigs, and pigeons, and which he has minutely described in Virchow's Archives, to devote further attention to this subject. Before I enter into a more detailed description of the facts observed, I will describe here especially the one observation on the human being, which appears to me very important in relation to the earliest processes after intra-ocular hemorrhage, and the question of absorption now under consideration, and is also not without interest in relation to the reaction of the vitreous toward foreign bodies.

C. Göbel, 22 years old. Upon the discharge of a fowling-piece, 30th May, 1869, a piece of percussion-cap flew into the right eye. The physician, consulted five minutes afterwards, noticed escape of aqueous humor, and a small wound in the cornea. Two hours afterwards the patient came to this Institute. The eye appeared to be but slightly irritated. In the upper inner quadrant of the cornea was seen a small linear wound, opposite to which there was also a wound of the iris. Anterior chamber normally deep. Pupil moderately contracted; reacts well. By means of the ophthalmoscope some floating cloudiness could be seen in the vitreous; the papilla distinctly visible. Good mydriasis after atropine. The canal of wound could now be distinctly seen in the lens; in the fundus of the eye we observed twice, upon movement of the eye, somewhat to the upper part and outside of the pupil, after numerous examinations, distinctly a reflecting metallic body, apparently of the size of one-third the diameter of the papilla. The same is covered when the eye is at rest by a dense floating obscuration of the vitreous, near which are some other slight opacities.

May 31st. During the night, from time to time stinging pain in the eye, pretty good mydriasis, moderate sub-conjuctival injection, beginning, cloudiness of the lens proceeding from the track of wound. Ophthalmoscopy still the same, only the metallic reflection is no longer visible.

June 1st. Pain increased; therefore enucleation of the bulb was performed. The eye was immediately put into Müller's solution, and on the 12th of June dissected. The bulb is of quite normal form. Cornea in the horizontal meridian somewhat longer than in the vertical. In the middle of the upper and inner quadrant is found a small, slightly bent, light stripe, traversing the thickness of the cornea, over which the epithelial layer is wanting. The iris is no longer to be distinguished clearly. The bulb is divided by a section in the equator into anterior and posterior halves. In the latter there is found, 5 mm. to the upper and external side of the papilla, upon the surface of the retina, a small whitish prominence, from which proceeds a thin white cord, which is still surrounded by a light lymph-like cloudiness finely striated. The thickness of the same is from 2 to 3 mm., and it extends towards the anterior part into the vitreous about 8 mm. in a straight direction. From thence it spreads a little irregularly and funnel-shaped, and encloses a brownish red mass, roundish in form, of from 4 to 5 mm. in diameter, which forms on its anterior extremity a reddish process, which is surrounded by a quite insignificant slightly transparent cloudy mass proceeding from the funnel-shaped opacity. It consists exclusively of red blood corpuscles surrounded by round cells, and the transformations of the same produced by contraction.

A great number of blood corpuscles were also found in the light, cloudy, lymph-like striated matter; at the same time, however, nearly an equal number of round cells, and interspersed among them a number of very small dark granules, here and there collected in heaps. The whiter centre of the stripe shows the same relations, except that the single elements, and especially the round cells, are crowded more densely together. The brownish red mass consists exclusively of well-preserved red corpuscles, with the normal proportions of white ones, which

are surrounded by the funnel-shaped zone consisting of round cells and their metamorphic forms. Besides this specially striking cloudiness in the vitreous we observe another, likewise at some distance from the optic nerve, proceeding from the retina and spreading itself out anteriorly in the form of a membrane. Here are seen embedded small brownish-red spots. With regard to the microscopic relation, these show no deviation from those described in the light string-shaped cloudiness. The small white swelling upon the retina consists of pus corpuscles, and in it is found a piece of percussion-cap 2 mm. in length, and $1\frac{1}{2}$ mm. in width. Fine incisions in the tumor and the adjoining parts of the retina and choroid show the following relations:—Immediately below the purulent mass the tissue of the retina could not be recognized; towards its margin the peripheric layers gradually appear distinctly, whilst the nerve layers and the granular layer are still for the most part filled with pus corpuscles. The latter become gradually less dense until the various layers become again distinct, and were visible only as isolated round cells in the most vascular layers of the retina. The pigment epithelium of the choroid was unaltered, and no change was perceptible in the stroma of that membrane. The anterior half of the bulb contains perfectly clear vitreous.

The posterior capsule of the lens shows, in the upper and inner quadrant, a distinct long oval fissure with a cloudy margin, from which no connection in the direction of the foreign body through the vitreous can be traced.

The connection between the scar of the cornea and the string-shaped cloudiness of the lens, and of the foreign body in the retina, forms a perfectly straight line.

In the *other case* the cornea was burst at its margin in consequence of a blow from a stick, the lens was lost, and a considerable effusion of blood took place into the eye. Extirpation seventeen days after the injury. The dissection took place after induration of the bulb in Müller's fluid for seven weeks. The anterior part of the space of the vitreous, from the commencement of the ciliary process to the posterior surface of the iris, was filled by a large blood extravasation.

Towards the posterior the same was separated by a yellowish white cloudy zone from the other parts of the vitreous. The same consists of fine filaments of newly formed connective tissue, with spindle and star shaped cells, and interspersed with larger and smaller round cells. The latter are especially numerous near the extravasation. They, like all other cell elements, contain a finely granular dark brown material.

Conditions quite analogous with the above described I had the opportunity to witness in my experiments on rabbits in a later stage. After having, with the ophthalmoscope, perceived in the later stages a diminution of the opacities, I could satisfy myself that the number of blood corpuscles had become relatively less; that they had even disappeared altogether in some spots; that, on the contrary, the contractile cells were filled with a matter varying from brownish red to yellowish red. I had several opportunities of observing cells provided with very various processes, in which I could distinctly perceive from one to two blood corpuscles. I have even observed that the red blood corpuscles had been, as it were, held fast by the processes of a contractile cell, and had been gradually absorbed by the same. Besides such variously shaped mostly distinct yellow or brownish red cells, were found, in some cases, distinct traces of young connective tissue.

After all these various observations I believe it may be accepted as true that process of resorption of blood extravasations in the vitreous take place by means of the red blood corpuscles being gradually enclosed in the contractile cells which are furnished from the surround-

ing vascular membranes. The latter change the coloring matter of the same to pigment, and may by further metamorphosis transform themselves into the cells of connective tissue in the vitreous. These observations form, therefore, in general a confirmation of the explanation of the processes of resorption, and especially in the vitreous, which was first described by *Langhans*.

Upon the third and last class of opacities, which may be considered as deposits and coagulations, in my estimation too little stress has hitherto been laid. *Von Graefe* has already drawn attention to the circumstance that the substance of the vitreous exposed to air becomes covered with a fine membrane consisting of a finely granular material. I have had several opportunities during my experiments of examining the cloudiness around bubbles of air, which developed themselves sometimes with striking rapidity, and I found nothing but a striated finely granular material surrounding the air-bubbles; the granules sometimes exhibited a lamellated arrangement, and it would appear sometimes as if the striation of the same had been produced by mere folding.

A very similar appearance is observed in the cloudiness produced by chemical reaction. Different degrees of density were observed in Exps. 6 and 29. In the latter I should like to draw attention to the peculiar process of resorption, which is quite similar to that in cases of blood extravasation. The contractile cells had absorbed particles of the original white silver albuminate, which, after some time, from the influence of light, showed very dis-

tinctly as black grains in the midst of these cells. The cloudiness around the piece of wire, as we have had occasion to observe in the other experiment, has already been minutely described. Such appearances can be very seldom observed, on account of the simultaneous injury of the surrounding membrane; in most cases exudations are found in the vitreous. In our experiment the cloudiness escaped the most attentive ophthalmoscopic examination and could only be proved upon dissection.

V. Graefe was the first to communicate that it may also happen in man under certain circumstances; that the foreign body lies free in the midst of the vitreous without any cloudiness. It is a pity that the results of dissection of such eyes are still completely wanting.

It has been stated from clinical observations and experiments that cloudiness of the vitreous developed itself around foreign bodies without any connection with the internal membranes. I by no means doubt the correctness of these observations; I would only draw attention to the necessity of separating inflammatory products in the vitreous from coagulations of the same, and that we must not conclude in every case in which we see cloudiness appear around a foreign body, that it is the result of an inflammatory process. My experiments, and the facts shown by dissection, compel me to the conclusion, that if as well ophthalmoscopically as later upon dissection no connection with the internal membranes can be proved, the same always consists of coagulation, and never of the products of inflammation.

Cloudiness occasioned by crystals of cholesterin I have never observed in any of my experiments. I would mention in conclusion that this paper, in by far its greater part, has been composed in the spring of this year, at the Anatomical Institute at Marburg. I joyfully take the opportunity of returning my hearty thanks to Profs. *Lieberkuehn* and *Wagener* for the very great kindness with which they placed the conveniences of the Institute at my disposal, as well as to my honored friend Dr. *Langhans*, Lecturer on Pathological Anatomy, for his manifold assistance in preparing this treatise.

WIESBADEN, 16th August, 1869.

INJURY OF THE LEFT EYE; SYMPATHETIC OPHTHALMIA OF THE RIGHT; LOSS OF VISION IN THE EYE SECONDARILY AFFECTED; VISION RETAINED IN THE INJURED EYE.

By THOMAS R. POOLEY, M.D., of New York,

Assistant-Surgeon to the New York Ophthalmic and Aural Institute, Clinical Assistant to the New York Eye and Ear Infirmary.

Ophthalmic surgeons are still divided in opinion as to the propriety of removing an injured eye, while it retains any power of vision, after sympathetic inflammation has declared itself in the other, and progressed to such an extent as seemingly to impair its function.

Cases are to be found scattered through the literature of the subject, in which, under such circumstances, the injured eye has eventually proved to be the more serviceable of the two. McKenzie, in his treatise on Diseases of the Eye, says:* "It is remarkable that the amaurotic affection of the eye which suffers sympathetically, is generally more complete than that of the eye

* McKenzie on Diseases of the Eye. Fourth edition, p. 611.

which was injured." Wells remarks * that, "If some degree of sight still lingers in the injured eye, and the sympathetic inflammation has already produced extensive injury, it should not be removed, for in some similar cases the injured eye has eventually proved of more use to the patient."

The following case is so strikingly corroborative of the correctness of these observations, that I have thought it worth reporting:—

D. M. R., æt. 32, a merchant, consulted me July 6th, 1869. Seven years ago, while breaking stone with a hammer, a piece of steel flew off from the hammer and struck him forcibly upon the left eyelid, through which it penetrated and entered the eye. The foreign body remained for some weeks in the eye (exactly how long he does not remember), and was then removed by his family physician. The wound healed; but two weeks later the eye began to be painful, red, and swollen. A week after the commencement of the trouble in the left eye, the right began to show signs of sympathetic irritation. He first noticed lachrymation, and then temporary obscurations of the visual field; subsequently this eye also became painful, red, and swollen. In two years the right, or sympathetically affected eye, had lost all perception of light. *The sight in the other, the injured eye, now began steadily to improve.*

His condition at the time he came under my observation was as follows:—There was a scar upon the upper

* Wells on Diseases of the Eye, p. 203.

sclero-corneal margin of the left eye, in which the iris was engaged, so as to form an anterior synechia and a pyriform pupil.

The iris, throughout its entire pupillary border, was attached to the capsule of the lens, immovable, and somewhat discolored. The pupil, with the exception of a small aperture, filled with a false membrane.

In the right eye the color of the iris was changed to a dirty green, and a dense opacity occupied the lower border of the cornea. The pupil was completely occluded by a false membrane, and the whole globe somewhat atrophied. Vision in the right eye was completely abolished, there being not even perception of light.

S. in the left eye $= \frac{2}{5}$. Tn. in the left eye; T. somewhat diminished in the right. The fundus of the left eye could be illuminated with the ophthalmoscope, but no details were discernible. For the last four or five years he has had recurrences of ciliary inflammation, with more or less pain in both eyes, *but always commencing in the right, or non-injured one.* The last attack took place about four months before I saw him.

I advised enucleation of the right eye, inasmuch as it evidently was now the source of irritation, and after its removal an iridectomy might with advantage be performed upon the other.

Dr. Knapp, who saw him with me in consultation, confirmed this opinion. The patient, however, refused to submit to the operation, and passed from under my observation.

SEROUS ACCUMULATIONS IN THE TYMPANUM.

BY S. MOOS, M D.

Translated by C. J. Blake, M.D., Boston.

For the first post-mortem observations upon the presence of serum, with or without mucus or lymph, we are indebted to Toynbee (see p. 227 of the German translation). He was also the first to draw attention to the marked analogy between serous membranes and the mucous membrane of the tympanum, urged the exceedingly small quantity of mucus which it secretes in the normal condition, and demonstrated the same by pointing out the exceeding thinness and smoothness of the membrane lining the tympanum, as also the frequency of adhesions resulting from inflammation in that cavity.

Following Toynbee, Voltolini at different times, in reports of post-mortems upon subjects who had been deaf, published in Virchow's Archives, and, more especially, in his inaugural essay (Examinations of the Ear in the Cadaver, Breslau, 1862), has also particularly described the peculiar characteristics of the mucous membrane of the tympanum as those of a serous membrane.

The first exact communications upon the accumulation of serous fluids in the tympanic cavity originated with Adam Politzer (Diagnosis and Treatment of the Accumulation of Serous Fluids in the Tympanum, Wiener Medicinische Wochenschrift, 1867, No. 16).

In the first case observed by him the diagnosis was facilitated by the membrana tympani not being affected by the disease in the tympanum. Owing to the absence of opacity there remained so marked a transparency of the membrane that the character of the contents of the tympanum could be clearly determined.

Two distinct parts were seen: the upper of a light color, filled with air; the lower darker in color, and corresponding to the fluid collected in the lower portion of the tympanum behind the membrana tympani; the boundary between the two being sharply marked, and distinguished by a fine black line, concave upon its upper border, and extending across from the posterior to the anterior periphery of the annulus tympanicus, at about the height of the middle of the manubrium mallei.

The appearance of this line could be compared to that of a black hair attached to the membrana tympani.

The patient being placed in a horizontal position, in a few minutes the black line changed its place and extended from the superior to the inferior periphery, the difference in color being observed in the anterior and posterior portions of the membrane. On returning the head to its normal position the appearance first observed returned also.

Following the application of an air-douche the difference in color of the membrane disappeared and examination disclosed a number of sharply marked black rings large and small.

The entrance of air into the tympanum occasioned the formation of bubbles in the serum. There could therefore be no doubt as to the diagnosis in this case.

In an article published later (Wiener Med. Presse, 1869, Ueber bewegliche Exsudate in der Trommelhöhle) Politzer again treats of the same subject, and more extensively, upon the ground of numerous observations. He describes the causes of the differing positions of the boundary-lines, their entire absence, and also mentions a characteristic, that, partly from the deflection of the rays of light reflected from the promontory, and partly from the yellowish color of the fluid in the tympanum, the gray color of the membrane is often tinted with a light bottle green.

Some of the patients had the sensation of the movement of a fluid in the middle ear when the head was inclined forwards, backwards, or sideways.

During a personal interview in 1869, in speaking of this subject, Politzer mentioned as a still more characteristic symptom the decided improvement in hearing following the use of air-douche, which, however, generally sank to the original minimum in a very short time, especially when the air-douche was not regularly continued. I have myself had opportunity of observing seven cases of serous exudation into the tympanum; five of

these were on both sides and four were relapsing, so that on the whole the material for observation could not be deemed scanty. In the following pages I shall describe the cases fully, and in conclusion attempt to present an accurate description drawn from the observations which have so far been made upon this subject, so important clinically and therapeutically.

CASE I.—*Serous accumulation in the tympanum on both sides. Reported to be the result of a wound. Paracentesis on both sides. Relapse on the right side. Paracentesis repeated. Final recovery. A legal case. Probable misrepresentation concerning the duration and cause of the affection.*

Johann Blind, 31 years old, joiner, sent to me on the 3d of May by Prof. Knauff.

History.—Patient asserts that up to six weeks ago he had never had trouble in his ears. The present attack he refers to a wound of the head received six weeks since in a scuffle. The wound was caused by a blow on the left side with a beer-glass, which broke upon the head, and necessitated his admission into the Academy Hospital; a slight erysipelatous inflammation manifested itself, which was treated, he says, by cold applications for eight days, followed for a short time by warm and then again by cold ones. About three weeks after the accident he states that he became deaf in the right ear, that is, in the side opposite the one on which the wound was received, and in this ear alone.

This trouble has continued without change since that time, and was accompanied by pain deep within the ear, "as if it would rush out." In addition, he has been annoyed by a continued throbbing in the right ear, which increases only on active exertion.

No symptom of otorrhœa; on the other hand, however, he admits, on being questioned, that he has suffered during the whole year from catarrh.

During the last two or three days he has had the sensation of a foreign body in the throat, from which he vainly attempts to free himself by constant "hawking."

Examination.—Numerous scars on the anterior part of the head and on the upper portion of the left side of the face, in consequence of the wound. Both external auditory canals large, and rather straight, without noticeable abnormality. Both membranes present about the same appearances, of a yellowish green (bottle green) color; manubrium nearly horizontal in position, with marked prominence of the posterior fold; centre very concave; continuity of peripheral zone broken. Light spot broadened at its base. Absence of any injection.

The catheter passed easily; auscultation gave a regular bubbling râle on the left side. The resistance to the injection of air on the right side was so great that auscultation was impossible, and the patient experienced positive sensations on this side only when the air-douche was repeated by means of Politzer's method. He exclaimed, "Now it has gone out at both ears."

On both sides the manubrial plexus was now seen to

be injected, more on the left than on the right side. however, the light spot somewhat decreased, the umbo somewhat lighter than before.

Hearing before the use of the air-douche:—Perception through the bones of the head on both sides. Voice in a loud tone, on the right side, 3 paces; on the left side, in a whisper, 8 paces. Watch (30 ft., normal hearing distance): Right, $7\frac{1}{2}$ inches; left, 24 inches. After the air-douche, right, $8\frac{1}{2}$ inches; left, 72 inches.

The mucous membrane of the nostrils was flecked with black crusts (patient being a joiner), and reddened. The glands of the pharynx were swollen.

Examination with the mirror showed the posterior wall of the pharynx covered with brownish crusts, and the orifices of the Eustachian tubes much reddened. Beyond this there was nothing of importance. In order to determine whether I had to do with a "malingerer" or no, I examined the patient with tuning-forks, according to the method described in the first number of these Archives.

With both ears free he affirmed that he heard the tuning-fork, when placed upon the head, in the left ear, and with the left ear closed, indistinctly in the right ear.

The examination being repeated, he reiterated his former statement.

On the 9th of May I exhibited the patient before the clinic, mentioning previously the possibility of there being dissimulation in the case, and the method for its detection; and on the patient's declaring himself to be

somewhat better, repeated the examination with the tuning-fork, when he stated that he heard the sound equally well on both sides when the ears were free, but only on the right side when the left ear was closed.

May 19th. Patient complains of increased deafness, and of being now affected in the left ear. The watch was heard at a distance of 1 inch, the voice at 2 paces. Conduction of sound through the bones of the head was perfect. The membranes presented the same appearances as before, a boundary-line demarking the level of the fluid in the tympanum from a space filled with air above it could not be distinguished. Nevertheless the appearance of both membranes left no doubt as to the presence of a serous exudation into the tympanum.

Paracentesis was therefore performed in the posterior inferior segment on both sides; the pain resulting from the operation was slight, and the air-douche, as subsequent examination showed, forced a large quantity of yellowish green fluid, mixed with air-bubbles, through both openings. A dark concave boundary-line was now seen at about the middle of the membrane. The hearing distance, tested with the watch, increased on the right side to 3, and on the left to 4 ft.

May 24th. No subjective noises, the perforations closed, and in the place of each a small dry spot of coagulated blood. The tympanic membranes pearl gray, with a "light spot." Hearing distance, with the watch, 15 ft., and the voice, in a whisper, at as great a distance as the room permitted (18 paces).

May 28th. Conduction through bones of the head present, but, without apparent cause, the hearing distance had decreased to 12 inches and 4 paces respectively.

During the last five days, on account of his work, and contrary to orders, he has omitted to present himself for the air-douche. The appearance of the tympanic membranes was the same as before the first paracentesis. The operation being performed a second time, the hearing distance increased to 23 inches and 18 paces for a voice of ordinary loudness; the following day, cicatrices having again formed, to the same distance for the voice in a whisper.

On this day, on examination with the tuning-fork, the patient for the first time gave reliable answers, and said that he heard in a higher tone with the left and in a lower tone with the right ear.

June 3d. The patient returned with a relapse in the left ear. Appearance of tympanic membrane the same as before the first operation. Conduction of sound through the bones of the head present. Watch 4 inches, voice 4 paces. The paracentesis liberated a quantity of yellowish-green serum, and the hearing distance increased up to the following day, when a cicatrix had again formed, to 5 ft. for the watch. There was no demarcation line observable after the operation.

June 8th. No subjective noises. Hearing distance: right ear, 2 ft.; left ear, 10 ft. Appearance of the right tympanic membrane the same as before the first opera-

tion. Following Politzer's air-douche, the hearing distance increased on the right side to 4 ft., and on the left to 15 ft., but without change in the position or color of the right tympanic membrane, etc.

June 20th. Hearing distance on the right side ½ inch. Conduction of sound through the bones of the head present. Continued rushing sounds in ear. Appearance of tympanic membrane the same as on June 8th. The condition of the left ear was normal.

Paracentesis was performed on the right side, very near the top of the posterior inferior segment. After the use of the air-douche much yellowish serum was found in the external meatus, and the rushing sounds had disappeared. Hearing distance 3 ft. A line of demarcation appeared as before, and the air-douche, repeated five hours later, ejected a still further quantity of yellow serum. The demarcation line then disappeared, and the hearing distance increased to 7 ft. After this visit the treatment consisted in the use of the air-douche, and local remedies to the pharynx; the right tympanic membrane soon regained its normal appearance, and the hearing power on both sides was perfectly satisfactory.

I did not see the patient again till the 10th of August, when he presented himself, and said that up to the afternoon of the 8th of August his hearing was satisfactory in every respect, and he had been perfectly free from all subjective trouble, but after a walk had observed rushing sounds, and a decrease of hearing in the right

ear. Up to this morning the subjective sounds had not disappeared, and at 7½ o'clock A.M. pain commenced behind and under the right ear and in the right temple. The hearing distance was 4 inches. Conduction of sound through the bones of the head present. The whole circumference of the tympanic membrane, the manubrial plexus, and the posterior half of the membrane were congested; the latter was more convex than the anterior portion, which appeared opaque. The light spot was quadrangular. The manubrium rather indistinct.

Paracentesis was immediately performed in the posterior portion, and a quantity of blood, but no serum, ejected. The rushing sounds and the pain ceased. Hearing distance 15 inches.

In the course of the day severe pain commenced, and was alleviated by repeated instillations of warm water. The night was passed without pain, but as often as the patient awoke he felt continued throbbing in the ear.

August 11th, A.M. Severe otorrhœa; the dermoid coat of the meatus raised; tympanic membrane grayish red, the posterior half convex and the anterior concave. The persistence of the perforation was determined only by auscultation during the air-douche; after the use of the latter the throbbing ceased.

August 12th. Moderate discharge. Objective symptoms the same as yesterday. Throbbing, ringing, and stinging in the ear. After the use of the air-douche the hearing distance was 15 inches.

August 13th. The perforation had closed. Occasion-

al rushing sounds and a shooting pain in the ear and temple. The whole tympanic membrane concave, and of a grayish-red color; the manubrium begins to be visible. Following Politzer's air-douche the hearing distance was 25 inches.

August 15th. External meatus and tympanic membrane dry, the latter very concave, the posterior portion and the manubrium congested, the anterior portion opaque. Continuous rushing sounds, and occasional shooting pains in the ear. Air-douche, rushing noises decreased; hearing distance six feet.

August 22d. The subjective noises have permanently disappeared, except that after active exertion he feels a throbbing in the right ear. The patient is free from pain, and is only occasionally troubled by an itching sensation. The circumference of the membrane and the manubrium are still injected, and an examination with a magnifying glass discloses a delicate injection of the radiating vessels. The membrane, which is very concave, is forced outwards by the use of the air-douche, while a distinct concussion is heard with the otoscope. Hearing distance two feet, and the voice in a whisper heard at a distance of eight paces. The patient has not since then presented himself.

This case is remarkable in several respects. The color of the tympanic membranes was characteristic of serous accumulations; the quantity of exudation was, however, so great, that a line of demarcation appeared only after a large proportion of the fluid had been ejected by

means of paracentesis and the air-douche. This excess of the secretion, and the great resistance offered to the passage of air through the Eustachian tube on the right side, prevented the patient from perceiving the effect of the air-douche.

The cause of the frequent relapses is traceable to the fact that the patient, at the time of the treatment, was frequently employed, in following his occupation as a joiner, outside of the workshop during the exceptionally cold and wet June of this year, and a methodical treatment following the paracentesis was rendered impossible. Continued attention should also have been especially directed to the treatment of the chronic affection of the pharynx and nasal passages. In fact, the relapses ceased permanently from the time such treatment was carried out; for the later affection was an acute catarrh, with convexity of the tympanic membrane, etc., a disease of a different character, from which he was speedily relieved by paracentesis.

Concerning the legal points, I would remark that the public proceedings in the case have not yet commenced. In my evidence, however, I shall especially mention that in all probability the patient had an affection of the ear before he received his injury, and would probably seek to take advantage of this circumstance in order to benefit himself pecuniarily.

The affection of the pharynx and nasal passages was undoubtedly of long standing, and the hearing had probably not remained intact. The examination proved

that the patient, who claimed to be deaf only in the right ear, the one opposite to the wounded side, was affected in the left ear also. At first he unquestionably dissimulated; this was clearly proved by the examination with the tuning-fork. Only later, when he found that the existence of his trouble was admitted, and that he was treated therefor,—when, in fact, he no longer feared that he would not be believed,—did he return correct answers when thus examined; this is additional evidence of his former dissimulation. An action for damages, on his part, would be set aside by the laws of any country; in the first place, because as an artisan, having free treatment, he incurred no expense; further, because the affection did not render him unfit for work; and finally, because the organ of hearing was ultimately restored to its normal condition, and neither surgeon nor judge would hold the person who inflicted the wound on the head responsible for the subsequent acute affection.

CASE II.—*Serous accumulation in the left tympanum, affording no indications on the tympanic membrane. Paracentesis but once performed. Permanent recovery.*

Mr. D., revenue officer, from Carlsruhe, was brought to me on the 10th of May, 1869, by his family physician, Dr. Deimling. Patient can give no definite explanation of the origin of his trouble. Has been affected for a long time by nasal catarrh, with copious secretion, especially in the morning, and has had a sensation of occlu-

sion of the left nasal passage (a subsequent examination showed this side to be less pervious than the right).

For several years the hearing power in the right ear has not been perfect, but within the last two months has very much decreased, especially on the left side. On this side there has also been a continuous singing noise, sometimes so severe as to interfere with mental exertion, and at times rendering him entirely incapable of following his occupation. He has also had occasional attacks of vertigo.

The hearing distance has decreased to 2 paces for the voice, and 2 inches for a watch of which the normal hearing distance is 30 ft. Conduction of sounds through the bones of the head absent. A tuning-fork placed upon the top of the head heard in the left ear. External meatus normal, manubrium drawn strongly inwards. Membrana tympani exhibits total opacity of the mucous membrane. Color bluish gray, and lustreless; no congestion; light spot diminished. Catheterization was easy, but there was at first great resistance to the passage of the air. The air-douche being persisted in, however, this was finally overcome, and the air entered more freely, causing distinct bubbling râles in the tympanum. The hearing distance increased to 18 paces and 1½ ft. respectively, a result which, according to both physician and patient, had never been attained by any previous catheterization. Each operation followed by improvement in hearing, which did not, however, continue. I expressed the opinion to Dr. D. that there was a serous exudation

into the tympanum, and advised the further treatment of the patient for a few weeks at home. Should there be no improvement I would then perform paracentesis. This advice was followed, but without benefit to the patient. The pharynx was touched with lunar caustic; the nasal-douche, gargles, and Politzer's air-douche employed, and Karlsbad water administered.

May 22d. The patient returned with about the same degree of hearing and the same trouble as before. I performed paracentesis in the post. inf. segment, following it immediately by Politzer's air-douche, and, for the sake of comparison, the catheter also. The injection of air through the catheter was now of course much easier than before, and so much serum was discharged into the meatus that it ran down over the lobule.

Patient heard a whisper the length of the room, and the watch at a distance of 12 inches; the subjective noises ceased almost entirely, and he felt the head to be much clearer. This was at 4 P.M. About 8 P.M. he felt very uncomfortable and had a chill. The night was passed quietly, however, without pain, and with but little subjective trouble. Slight discharge from the ear.

May 23d, A.M. Hearing distance 14 inches, and 10 paces for a whisper.

Communication of sounds through the bones of the head perfect, a small quantity of secretion in the external meatus, manubrium injected and less drawn inwards, slight swelling of the edges of the perforation. On catheterization the middle ear was found to be quite free,

though much serum was still present. Hearing distance 18 inches. The feeling of deafness on the side affected had disappeared. General condition very good; in the evening, however, there was a little feverishness.

May 24th. Perforation closed, watch heard at a distance of 1 ft. Sound in the ear as of distant boiling water. Towards evening an attack of vertigo so severe that I was sent for. The attack continued after he had been placed in bed. Hearing the same.

May 25th, A.M. Following a good night's rest another attack of vertigo. Hearing the same; sensation of itching in external meatus, and the same noise in the ear as yesterday. On catheterization the Eustachian tube was found to be readily permeable. The treatment of the pharynx and nasal passages was recommenced.

May 26th. Less vertigo. Watch heard at a distance of 15 ft., and the voice, in a whisper, at 18 paces (a greater distance was not obtainable). The ticking of a cylinder watch was heard through the bones of the head, and the hearing distance with the same watch was 1 ft. No subjective noises.

The patient remained under my care till June 5th, at which time the hearing was perfectly good, so that the family physician wrote to me to express his surprise at the result. There was but one attack of vertigo during the latter part of the time that he was under treatment; but he was never entirely free from dizziness, and after his return this trouble increased in frequency and severity, although precautionary treatment was continued.

Finally, the administration of Emser Kränchen * having been continued for some time for a chronic gastritis, the vertigo permanently disappeared.

September 5th. I saw the patient for the last time. He rejoiced in his general good health in every respect, and was still in possession of good hearing. He could pursue his occupation undisturbed.

In this case we plainly had to deal with a chronic catarrh of the middle ear. The condition of the mucous coat of the tympanic membrane (see the description of its appearance) had become so changed from this cause that it was impossible to diagnosticate a serous accumulation in the tympanum from examination with the ear-mirror; and this diagnosis was arrived at more from auscultation, and the fact that a marked variation in hearing was observed immediately after the air-douche, and during the pauses following it.

The subsequent improvement in hearing showed that decided changes could not have taken place in the sound-conducting apparatus. The subjective noises and the arrest of perception of sound conveyed through the bones of the head must be traced to increased intra-auricular pressure resulting from the large quantity of exudation, more especially as after the liberation of the same the perception of sounds conveyed through the bones of the head speedily returned, even with a fine cylinder watch, and the subjective noises rapidly decreased. The tem-

* One of the Mineral Springs at Ems.—C. J. B.

porary decrease of hearing power following the cicatrization of the perforation is nothing unusual, and has often been observed in other cases.

The severe attacks of vertigo following the paracentesis are remarkable; exactly the opposite would have been expected; and precisely on this account I do not believe that the cause was to be sought for in the ear, the less so as they entirely disappeared after treatment directed to the relief of gastric trouble. It is difficult to say how long the exudation had existed in the tympanum, but it had probably been present at least two months. Whether serious changes will occur in the middle ear in the future is not easily foretold. Considering the course of the disease during the first three months after the paracentesis, the prognosis in this respect would be rather favorable than otherwise.

CASE III.—*Serous accumulation in the tympanum on both sides; paracentesis on both sides, repeated on the right; otorrhœa of short duration; formation of furuncles in both external ears. Recovery.*

M. M., nine years old, from Philadelphia, was brought to me by his mother on the 20th of March, 1869. The boy had suffered for a long time from a continuous discharge from the nose, copious secretion of mucus in the throat, and for the last few weeks had not been able to sleep with his mouth closed. His hearing, which had been dull "for a long time," had latterly decreased in an alarming manner. On both sides a loud voice could

be heard only at a distance of two paces, and the watch (normal hearing distance, thirty feet) at a distance of nine inches. Conduction of sound through the bones of the head was present for the watch only. The upper lip was excoriated by the continued discharge from the nose, and the mucous membrane of the latter very much inflamed. Breathing through the nose was accomplished with difficulty. On depressing the tongue, the tonsils and glands of the mucous membrane, at the back of the pharynx, appeared swollen, while at the same time a quantity of mucus was forced down from the upper part of the pharynx by the pressure on the tongue. There was no trace of injection on the tympanic membrane or manubrium, which was drawn strongly inwards on both sides. The tympanic membranes were very concave, of a peculiar blue-black color, and very transparent.

With common illumination, and still more clearly by reflected sunlight, there was seen on the right side a grayish black line, concave, and passing from before backwards across the end of the manubrium. It had the appearance of a "grayish black hair," fastened upon the mucous coat of the membrane; the coloring of the membrane was different, being more of a yellowish green. Treatment with Politzer's air-douche, continued for three days, resulted in a decided improvement in hearing. On the 5th of April, however, this had decreased to its former minimum. April 5th, I performed paracentesis on the right side, following it immediately with the air-douche, which was repeated several times up to the 9th.

On the 5th and 6th a quantity of straw-yellow stringy secretion was discharged. On the 9th, an examination with the mirror and test of hearing-power showed apparent return to the normal condition. I then performed paracentesis on the left side, and in this case the demarcation line showing the level of the fluid appeared only after the operation. Otorrhœa and circumscribed inflammation in the external meatus, accompanied by severe pain, followed. This condition existed on the 15th of April. After closure of the perforation, which occurred on the 13th, the air-douche was continued every day till the 17th, then omitted till the 21st.

The condition of the right ear on that day was unfortunately the same as before the first paracentesis—the same in every respect except that the quantity of serum appeared to be greater, as there was no line of demarcation.

I repeated the paracentesis with the same result as before, except that a line of demarcation was not at this time observable. A quantity of fluid, presenting the same appearance as before, was, however, ejected.

Otorrhœa and follicular abscesses in the external meatus followed this operation also, and it was not till the 28th of April that the normal condition returned. The subsequent treatment was directed to the condition of the pharynx and nasal passages.

This case is noticeable inasmuch as the loss of hearing was the same on both sides, notwithstanding the great difference in the quantity of the secretion; the degree of

deafness, therefore, does not depend entirely on the amount of fluid secreted, especially in cases accompanied by impermeability of the Eustachian tube. The relapse, and the occurrence of suppuration in the tympanum after paracentesis, are worthy of notice. The latter was probably the result of the operation and the follicular inflammation in the meatus.

Case IV.—*Serous accumulation in the right tympanum. Small quantity of serum. The demarcation indicated by two divergent descending lines. Paracentesis. Subsequent otitis media and formation of furuncles in ext. meatus.*

Mr. S., school-teacher, consulted me on the 1st of June, 1869. According to his statement (which was confirmed by subsequent examination), he has been deaf in the left ear for the past two years, without any cause of which he was aware, and has also been troubled by continued subjective noises. Up to the 27th of May the right ear was in normal condition; at that time he took part in a procession on Corpus-Christi day, perspired freely, especially about the head, and was exposed to a draught of air. On the 29th severe vertigo occurred, rushing sounds, and loss of hearing on the right side. There has been no improvement in any of these symptoms, with exception of the rushing sound, which is not continuous, as it was at first, but occurs only occasionally.

Examination.—Hyperæmia of the inner end of the external meatus and the manubrial plexus, the superior half of the tympanic membrane lustrous; through the

lower half there can be seen a collection of fluid in the tympanum, and the appearance is exactly the same as that described by Politzer and given in the second illustration of his work. The fluid was bounded by two lines, commencing at the lower end of the manubrium and diverging with a slight curvature downwards. Conduction of sound through the bones of the head; the examination with the tuning-fork was without definite result. The voice was heard at a distance of 5 paces, and the watch at 1 ft. (in place of 30 ft.). Paracentesis was performed, and a small quantity of serum, but a good deal of blood, came through the opening. Hearing distance 2 ft. The diverging lines of demarcation have disappeared. The operation was immediately followed by pain, sense of fulness in the head, and a rapid injection of the whole tympanic membrane, and later a copious discharge and active inflammation of the membrane and the tympanum. The perception of sound through the bones of the head was lost, a steady rushing sound came on, and the hearing distance decreased to 3 inches.

June 7th. Abatement of the preceding symptoms.

June 8th. Symptoms of circumscribed inflammation in the external meatus.

June 12th. Freedom from pain, no discharge, and no subjective noises. Meatus still somewhat occluded. Perforation closed. Hyperæmia about the manubrium; tympanic membrane grayish red. Hearing distance 2 ft.

Perception of the voice is so good that the patient will await the further development of his case at home.

In the above case the peculiar appearance of the memb. tymp. is remarkable; as yet I have seen it only in this one instance. Politzer explains it by the supposition that the quantity of fluid in the tympanum being small, it is distributed in the situation described by the adherence of the approximated surfaces of the central portion of the tympanic membrane and the promontory.

So great a degree of disturbance in hearing would hardly have been expected from the presence of so small a quantity of fluid in the lower part of the tympanum, and this gave rise to the suspicion that the right ear had not been in a normal condition for some time previous to the acute attack (such had been the case in the left ear for two years).

The otitis and formation of furuncles which followed the paracentesis I trace to that operation. Though I may consider the result in the hearing gained to the patient a satisfactory one, because being totally deaf on the left side his occupation as a school-teacher obliged him to depend upon his right ear, still I freely confess that in a like case I should not be so ready in performing paracentesis, at least till I had made the attempt for a sufficient length of time to determine whether or no so small a quantity of fluid could be removed without the assistance of an operation. In this connection I would especially remark, that at the time of my treatment of this case I was not aware of the experiment advised by Politzer in his second article on this subject, the head being thrown backwards or bent far forwards during the air-douche.

Case V.—*Serous accumulation in the tympanum on both sides. Paracentesis on both sides. Hearing restored. Continuance of subjective noises on the left side.*

S., 29 years old, merchant, from the Palatinate, consulted me for the first time on the 25th of May, 1869. Has been troubled for several years with "catarrh and mucus in the throat;" for the last five years has had trouble in his ears. At the commencement he was first affected with a rushing sound in the left ear; there were long pauses, however, so that sometimes for half a year he would be without subjective noise or diminution of hearing, and it is only lately that he has experienced loss of hearing on the right side. Subjective noises have never been present in this ear. In both ears the meatus is normal in every respect, and there is no sign of injection either in the tympanic membrane or about the manubrium mallei. The right membrane is very concave, the posterior portion grayish green, the anterior of a tendinous white color, the light spot broadened.

The left tympanic membrane is furrowed at its periphery, and exhibits numerous light spots. The post. half appears grayish yellow, the anterior tendinous white. No demarcation line on either side. Hearing distance, right side 6 inches (in place of 6 ft.), left side, with the watch, 1 ft. (in place of 30 ft.). Voice at a distance of 6 paces.

Great resistance to the injection of air with the catheter; on both sides fine seething and bubbling râles were heard on auscultation. Hearing distance, right ear 1 ft.

(in place of 6 ft. with a common watch), left ear 4 ft. (in place of 30 ft. with a test watch).

On the right side the common watch, and on the left side only the test watch are heard through the bones of the head. Tuning-fork heard in the left ear when placed upon the head. I advised the patient to put himself under my care for a short time.

June 3d. He came to me in about the same condition as before, and the air-douche had the same result as at the first visit.

The next morning I exhibited the patient to the class, gave the reasons for a diagnosis of a collection of serum in the tympanum on both sides, and performed paracentesis in the post. inf. segment of both membranes. The operation[1] was followed by Politzer's air-douche. A quantity of yellowish green serum was forced out on both sides, and in the left ear ran down over the lobule. A concave line of demarcation was now seen, extending from the end of the manubrium across to the posterior periphery; the anterior half of the membrane was evidently too opaque. More serum being ejected, the line of demarcation disappeared. Hearing distance, right ear 12 inches, left ear 15 ft., and with a common watch 3 inches. Subjective noises lessened, but have not wholly disappeared. Manubrial plexus somewhat injected.

3 P.M. Hearing distance on both sides the same as in the morning; appearance of manubrial plexus also the same. The tympanic membranes of a silk gray color,

shining, but the numerous light spots have disappeared from the left side.

The perforations still exist. Air-douche repeated.

June 5th, A.M. Both perforations cicatrized. Commenced treatment of the pharynx and nasal passages according to the usual method. Air-douche continued.

June 7th. A common watch heard at a distance of 12 inches in the right ear, and 7 inches in the left.

Subjective noises in the left ear continue. Air-douche by means of the catheter on the left side. Hearing distance, 11 inches.

June 11th. The patient had the normal degree of hearing in the right ear, and 4 inches in the left. A common watch was heard through the bones of the head, and the perception of common conversation was excellent, but the noises in the left ear continued. He was instructed in the use of Politzer's air-douche, and advised to employ it three times a week, and to report himself on the appearance of the least trouble in the ear, but up to this time has not presented himself.

In the preceding case we had a catarrhal inflammation of the middle ear, of long standing, to which was subsequently added a serous exudation into the tympanum, on both sides. As proofs of the long continuance of the trouble in the middle ear, we have the fact that the characteristic coloring of the tympanic membrane was not seen over the whole surface, because a portion of the mucous coat had become very opaque; and for the same reason the line of demarcation which occurred on

the left side, after liberation of a portion of the secretion, was only visible through the posterior half of the membrane; and in addition, the persistency of the rushing sounds, which remained in the left ear at the conclusion of the treatment, and the diminution of hearing power in this ear as compared with the right.

The mucous membrane of the tympanum, from long contact with the exudation, had evidently undergone changes which would not permit perfect restoration, a circumstance which, taken in connection with the persistence of the subjective noises, tends to make the prognosis for the left ear rather unfavorable, and leads to the apprehension of the development, slow but progressive, of a chronic catarrh of the middle ear.

CASE VI.—*Serous accumulation in the tympanum on both sides. Absence of the characteristic appearances of the membrana tympani. Paracentesis and relapse on both sides, followed by the first appearance of characteristic symptoms on the left side. Repetition of the paracentesis on both sides. Repeated myringitis, resulting from the operation on the right side.*

Valentin Füg, 25 years old, trumpeter in the dragoon regiment in Bruchsal, consulted me on the 8th of June, 1869.

For thirteen weeks has had trouble in both ears, incapacitating him from duty.

The affection was preceded for some time by "cold in the head, and catarrh;" commenced with noises in the

ears, first on the right, and then on the left side; finally this ceased on the left, but has continued up to date on the right side. The hearing decreased in an alarming manner, and latterly the tones of his instrument have been a torture to him; at first he believed that his comrades were playing out of tune.

Examination.—The form of the external meatus, on both sides, was such that it was impossible to get a view of the anterior inferior segment. So far as can be seen, the inner end of the meatus and the manubrial plexus on both sides are injected. The tympanic membranes are very concave, opaque, and indicate the presence of serum; on both sides the manubrium is nearly horizontal, beyond this nothing of importance. Hearing distance, right ear, 5 inches; left ear, 7 inches. (Test watch of 30 ft. hearing distance.) Conduction of sound through the bones of the head present. On catheterization there was at first great resistance to the entrance of air, especially on the right side; finally, however, a fine bubbling rattling râle was heard on the left side; at first a creaking sound only was heard; this remained on the right side, but changed as above described on the left.

The hearing distance increased on both sides to 4 ft., and the sounds disappeared.

June 10th. Hearing has decreased, but the subjective noises have not returned; the air-douche was repeated with the same result as before, but on the 18th of June the hearing had become as bad as before the first treatment, and the sounds returned with the same intensity.

Notwithstanding the absence of any appearance characteristic of a collection of serum in the tympanum, I considered that such was the case on both sides, judging from the results of the auscultation and the variation in hearing power before and after the use of the air-douche. I performed paracentesis in the posterior inferior segment on both sides. Following Politzer's air-douche, a quantity of a wine-yellow fluid appeared on the outside of the left membrana tympani; on the right side the only change was in the disappearance of the noises. There was no trace of fluid, and it made its appearance only on a repetition of the air-douche, and then in as large a quantity as from the other ear. After removal of the fluid, the edges of the perforation in the right ear were seen to be colored with blood. Hearing distance 20 feet. A common watch was heard at a distance of 11 inches in the right, and 9 inches in the left ear. Three hours later the perforation on the left side appeared to have closed. The noises had disappeared, the external passages were dry. The air-douche was repeated with positive and negative results on the left and right sides respectively. It was necessary to catheterize the right side before getting subjective and objective symptoms of the passage of the air. There were no rattling râles perceivable. A common watch was heard at a distance of 13 inches. This degree of hearing was retained at the date of the next visit on June 21st, by which time the perforation had closed.

Severe pain, with rushing and pulsating sounds, com-

menced in the right ear on the evening of the 18th of June, together with a discharge which has continued up to the 21st. The memb. tymp. was grayish red in color, covered with pus, and having a pulsating bubble in the perforation. Politzer's air-douche was employed without result, and the catheter was necessary to clear the passage. The noises were silenced, and the hearing distance increased from 1 to 4 inches (tested with a common watch).

June 23d. Hearing distance, right ear, 4 inches; left ear, 18 inches. No return of pain; a rushing sound in the right ear, but no throbbing, and but slight discharge. Appearance of memb. tymp. the same as at last examination.

Politzer's air-douche was employed without result on the right side; but after catheterization the hearing distance increased to 6 inches, and the noises disappeared.

June 30th. Since the last visit the patient has performed with his band several times—twice till long past midnight—and in addition to this has led a very irregular life. The rushing noises have returned on the right side, and the hearing has decreased to 1 inch; on the left side to 5 inches.

The appearance in the right ear is the same as it was before, while the left memb. tymp. has a peculiar earthy color, is very concave, the light spot dim, and the manubrium prominent. There is no line of demarcation.

Politzer's air-douche was perceived in the left, but not in the right ear.

Hearing distance on the right side 2 inches, on the left side 7 inches, without essential influence on the condition of the left memb. tymp. The use of the catheter in the right ear forced a passage and increased the hearing to 4 inches. Paracentesis was performed in the posterior inferior segment on the left side, and followed by Politzer's air-douche, which was perceived in both ears. A quantity of stringy serum was found in the left ear. Hearing distance on the right side 5 inches, on the left side 12 inches.

July 3d. Left tympanic membrane normal in position and color, with a brown spot upon the cicatrix of the perforation. Hearing distance 26 inches. A common watch was heard in the right ear at a distance of 1 inch. No perforation, and the secretion has ceased. Memb. tymp. of a grayish-red color; manubrium not yet visible. Continuous rushing noises. Politzer's air-douche without result. The use of the catheter increased the hearing distance to 4 inches, and gave the same results on auscultation as at the first visit.

July 10th. The same. At this visit the injection of air could be accomplished neither with Politzer's air-pump (compressed air at a pressure of from 1 to 1½ atmospheres) nor with the catheter. Hearing distance 2 inches. Conduction of sound through the bones of the head present. Memb. tymp. is still covered. Paracentesis was again performed in the posterior inferior segment, and Politzer's air-douche employed, but still without result. Catheterization forced out a quantity of a reddish-yellow fluid, the

rushing sounds disappeared, and the hearing distance increased to 6 inches.

July 11th. Hearing distance 4 inches. Occasional rushing noises at intervals of several hours. Fresh symptoms of myringitis.

July 14th. The same. The perforation remains. Hearing distance 6 inches. Continuous rushing sounds and a watery discharge from the ear. Politzer's air-douche employed without, and the catheter with, result. From this time I lost sight of the patient.

This case is noteworthy on several accounts. It is particularly remarkable that, notwithstanding the repeated return of the serous exudation in the tympanum, an appearance of the memb. tymp. characteristic of this lesion was only once observed,—an earth-colored appearance of the membrane,—but without the presence of a line of demarcation. This was due at first to the serous infiltration of both tympanic membranes, and later to the changes induced in the right memb. tymp. by the previous inflammation.

The marked difference in the permeability of the Eustachian tubes, and in the resistance to the entrance of air on both sides, is of interest.

On the right side it was always more decided than on the left, and, as the history shows, returned in so great a degree that Politzer's air-douche was often ineffectual—once even when it was employed in connection with catheterization, and again when administered immediately after paracentesis.

The cause of the frequent relapses is plainly traceable to the repeated closure of the Eustachian tubes.

In performing paracentesis in a like case it would be more to the purpose and more advantageous to treatment to operate first upon the side offering the greatest resistance in such case. Politzer's air-douche might succeed better than when paracentesis on the opposite side had decreased resistance in the middle ear by the presence of an artificial perforation, as the air, on being forced in, would tend naturally to the side offering the least resistance. With so great a degree of resistance in the right tympanum it is remarkable that no fluid was ejected by the air-douche after paracentesis on this side. At first I believed that I had made a mistake in the diagnosis. The reactionary inflammation appearing upon the right side is traceable in part to the operation, but in a greater degree to the irregular and unhealthy mode of life resulting from the patient's occupation.

In answer to a written inquiry, I learned that the patient had omitted treatment on account of duty; that the recovery on the left side was perfect, but that he intended to consult me again on account of the right ear; but up to this time he has not done so.

CASE VII.—*Rapid accumulation of serum in both tympanic cavities. Paracentesis on both sides. Sudden restoration of hearing.*

Christoph Ludwig Weimar, 23 years old, tailor, from Wertheim. Three weeks ago he first noticed a dull feel-

ing in the head, difficulty in swallowing, and increased secretion of mucus in the throat, with rapid diminution of hearing on both sides; at the same time the patient had a continued sensation of sound in the head, compared to the rushing of steam from a boiler. The trouble developed without pain. In the morning the hearing was better than during the remainder of the day.

Examination.—Both tonsils much enlarged. Catarrh of the pharynx and nasal passages. Great resistance to the injection of air. Direct catheterization gave a regular bubbling râle. Both external ears normal. Both tympanic membranes of a chocolate color, the manubrium white, the membrane rather flat, the centre somewhat darker than the periphery, and without a light spot. But slight perception of sounds conducted through the bones of the head. The watch was heard at a distance of 1½ inch, and after the air-douche at 18 inches.

No line of demarcation observable either before or after the air-douche.

Paracentesis in the post. inf. segment on both sides, followed by the air-douche, liberated a great deal of greenish-yellow serum, which did not mix readily with the water when the ears were syringed, and remained sticking in the incisura intertragica. Perception of sound through the bones of the head is much increased. The watch is heard on both sides at a distance of 15 ft. Memb. tymp. now of a dull gray color, with a light spot on the right but none on the left side. Manubrial plexus in both ears is injected.

The next morning at 8 o'clock.—Operation not followed by the slightest reaction, the night passed well and without pain, and the subjective noises did not return. The hearing not quite so good as immediately after the operation. Both external passages dry. The memb. tymp. appeared the same as after the operation, and the presence of an artificial opening was only perceived on auscultation.

On the repetition of the air-douche a rather large quantity of greenish-red serum was seen in both ears, more in the right than the left, so much indeed that the niche formed by the membrane and the inferior wall of the meatus was filled full, and the lower half of the membrane hidden by the serum. The hearing distance, as tested with a common watch (of 6 ft. hearing distance), reached 4 ft.

An examination with the rhinoscope revealed excessive catarrh of the naso-pharyngeal cavity. It was necessary, in order to obtain a clear view, to cleanse it with the douche, which showed the condition commonly found in fresh catarrh of this region, and implication of the ostium pharyngeum tubæ (yellowish-green secretion at the entrance on both sides).

Notwithstanding the use of the nasal douche, a great deal of mucus still remained in Rosenmüller's fossa. I have already spoken of the condition of the tonsils. The patient did not again present himself for examination.

This case is marked by the development of a great degree of deafness in a very short time.

This was evidently caused in part by the closure of the Eustachian tubes, and in part by the quantity of the exudation, sufficient to fill even the upper part of the tympanum; the latter circumstance accounts for the absence of a line of demarcation. The coloring of the tympanic membranes was not bottle-green, but rather resembling chocolate.

The position was inconsiderably changed, and the great quantity of exudation would undoubtedly account for the absence of the characteristic appearance of the membrana tympani, notwithstanding the closure of the Eustachian tubes.

The fact that the hearing was better in the morning is probably due to the position on the back during the night, allowing the serum to flow away from the structures important to the transmission of sound (the ossicles and the fenestra), so that there was less obstruction during the first hours of the morning.

I should not consider the patient safe from relapse, as he abandoned further treatment.

EPICRITIC REMARKS UPON THE ABOVE CASES.

With exception of a boy 9 years of age, all the subjects were adult males.

The conjectural duration of the disease extended from 4 days to 3 weeks.

The immediate cause could be determined in one case only—a draught of air upon the head when perspiring.

In the remaining cases the affection must be considered a secondary one, an extension of the catarrhal inflammation from the nares and pharynx to the Eustachian tube. The degree in which inflammation and adhesion of the walls of the tube may influence a serous exudation into the tympanum has been clearly demonstrated by Politzer (l. c.), who says that the adhesion not only prevents the discharge of the secretions of the tympanum, but results in rarefaction of the air, and consequent decreased pressure upon the blood-vessels, which are frequently in a state of congestion from the extension of the irritation to the tympanic walls.

Continuous subjective noises were present in 4 cases; interrupted subjective noises in 2 cases,—in one so severe that the continued singing had a disturbing effect upon the mental action of the patient. In the majority of the cases these noises were removed by the introductory treatment; in one case they disappeared entirely only after a long course of treatment following paracentesis; in another case they persisted, and made an unfavorable symptom for the prognosis. Where they had once existed and been dispelled by treatment they returned on the occurrence of a relapse, and remained, as a rule, during its whole course.

In those cases where all signs of congestion were absent, the subjective noises could be taken as conclusive evidence of existing pressure, and where they persisted after paracentesis, as symptomatic of serious changes in the tympanum.

Vertigo was present in two cases; in one of these it continued after paracentesis had been performed, and was probably due to gastric trouble (see Case II.). In all those cases which ran their course independently, that is to say, without inflammatory complications, there was freedom from pain. In six of the cases, aside from complications, the external ear was free. In No. IV. only, which was a fresh case, the inner end of the meatus was congested, and the injection of the upper wall continued into the manubrial plexus; the latter alone was congested in one other case. The position, inclination, and curve of the tympanic membrane was unchanged in but two cases. As a rule, its concavity was very much increased, the manubrium drawn inwards or horizontally, in one case exceedingly light in color; the periphery was furrowed, etc. The causes of these varying appearances may be sought for, in part, in the different character of the illumination employed for the examinations, and in part in the varying color and consistency of the fluid itself. The color was not always bottle-green, but sometimes chocolate, bluish black, grayish green, or earthy. Where the mucous coat was either wholly or partially opaque, in consequence of the long participation of the tympanum in the catarrhal process, the characteristic coloring was either entirely or partly wanting in the anterior half of the membrane, as for example in Case V.

In Case VI. the symptomatic coloring was absent on both sides, in consequence of serous infiltration of the tympanic membranes. In one case the light spot was

wanting on both sides, but reappeared normally on one side after the paracentesis, and in one case it was multiplied. As a rule, it corresponded in appearance to the increased concavity of the membrane. But three cases were discharged with the memb. tymp. in normal condition. The "demarcation line" was absent in all the cases, relapses included, with the exception of two. In the majority this was caused by the large quantity of the serous secretion, as it was generally seen after paracentesis when the transparency of the membrane allowed.

The fact that air-bubbles were never observed in the fluid after the air-douche, was probably due to the resistance in the Eustachian tube and the quantity of the fluid, the air entering with difficulty, and where it did gain admission to the tympanum, the condition of the memb. tymp. was unfavorable to a view, on account of its loss of transparency. We have already spoken of the great resistance to injection of air through the Eustachian tube in several of the cases—Case VI. especially—and in one other where it prevented the ejection of the serum through the perforation in the membrane.

The sounds on auscultation corresponded to this condition; there was either a low creaking sound, imperceptible to the patient, during the whole of the air-douche, or a regular bubbling, rattling râle in the tympanum at the close, when the resistance had been overcome, or at the commencement, when it was not too great.

The conduction of sound through the bones of the

head was perfectly normal in Cases I., III., IV., and VI., some of them being affected on both sides. It was absent in Case II., diminished on both sides in Case VII., and varied in Case V., a common watch being heard on the right side, while only the test watch was perceived on the left. In all cases where it was diminished, or entirely absent, it returned in a normal degree after treatment.

The hearing power was much decreased in all the cases, and the great fluctuations which Politzer considers characteristic when a decided decrease commences in the pauses of treatment, were particularly noticeable in Cases I., II., and V. Increase of hearing on awakening in the morning distinguished Case VII. only.

Resonance of the voice was not observed by any of the patients, even in those where the affection was limited to one side, nor were any statements made from which the conclusion could be drawn that there was a sensation of movement in the middle ear. It seems to me that this symptom is more probable in those cases where the quantity of fluid collected is not so great.

These subjective phenomena may be characteristic in many cases. I do not consider them as pathognomonic, however, even when accompanied by a coëtaneous increase of the hearing power and resonance of the voice, referring especially to the observations made in the following case. It is given as I observed it, though it ends in an enigma.

Catarrh of the Eustachian tube on both sides. Sensation of the movement of a fluid in the ear accompanied

by improvement in hearing. Sensation of resonance. Paracentesis performed with negative result.

M., 60 years old, merchant, has suffered for eight months from pain in the temple and forehead, especially over the left orbit, and accompanied by a feeling of pressure in the left eye,—the latter, however, only exceptionally present. From time to time these pains increased, extending to the right side of the head (there were no spots of tenderness). Latterly a sensation of stoppage in the nose and in both ears has been added to the other discomforts. (Bromide of potassium, quinine, iron, and the whey-cure gave no relief.)

"If I recline my head," said the patient, "I feel a movement in the ears, especially in the left one, and the ears are suddenly freed from the stoppage; the longer my head rests the more free it is. When I awake in the morning my ears are perfectly free and the hearing good; but so soon as I raise my head erect the left ear fills itself, and shortly afterwards the right also, and I hear much worse. The head is never entirely free from pain, not even after long remaining in a horizontal position." The patient denied ever having had pain in the ears, discharge, subjective noises, or vertigo.

The examination showed both external ears normal. Both tympanic membranes were slightly opaque; beyond this, either in respect to position or hyperæmia, etc., there was no noticeable abnormality. These appearances remained unchanged when the patient bent his head forward. He made the same statement with regard to the

sensation as before, but neither a line of demarcation nor other noticeable change appeared. The hearing distance with the watch was 1½ inch on the right side, and 1 inch on the left.

The voice in the common tone of conversation was heard at a distance of from 8 to 10 paces. The watch was heard through the bones of the head on both sides, but the examination with the tuning-fork was negative in its results. On the patient being caused to place himself in the position above described, a gradual increase in the hearing power could be determined with the tests instituted for the purpose. It increased in proportion as the head was inclined forwards; on the right side it became 4 ft. for the watch, and 18 paces with the voice in a whisper, whereas on the left side it reached the normal standard—30 ft. for the watch.

The head being returned to an erect position, in a few minutes the same diminution in the hearing power appeared as before the experiment. The remarks with which the patient accompanied the movements of the head were curious. With the head inclined forwards, "Now the ear is empty." When in an upright position, "Now it is filling again."

On using Politzer's air-douche he experienced no sensation, neither could I determine any important increase in hearing power thereafter. I now essayed catheterization, and ausculted at the same time. There was a marked difference between the two sides; this difference was also noticed by the patient. Scarcely any air entered on

the right side, and the resulting râle resembled a faint creaking; the patient had no sensation from it in the middle ear, and the hearing power was not increased. On the left side, on the contrary, I heard, as if it were in my own ear, a loud blowing sound, readily perceived by the patient, and unaccompanied by bubbling râles. There was an immediate increase in the hearing distance of from 3 to 4 inches. After the operation there was injection of the manubrial plexus on both sides, but otherwise no perceivable change.

By the time of his departure the hearing was the same as before the examination. There was no change in the condition of the head, nor in the resonance of his voice; this latter symptom I had forgotten to mention. He described it very characteristically in the words, "It often seems to me, when I speak, as if I had an echo on the left side of my head."

When the patient presented himself four days later the condition of things was very nearly the same. Hearing distance (measured with the test watch of 30 ft., normal distance), right ear 12 inches, left ear 16 inches.

Politzer's air-douche was employed, the head being inclined forwards, but without change. On catheterization the hearing distance increased to 21 inches in the right ear, and 24 inches in the left. I made an examination with the rhinoscope, but could perceive nothing more than a catarrh of the pharynx. The pharyngeal openings of both Eustachian tubes were small, but beyond this nothing remarkable was observed.

The patient perceived no cracking sounds accompanying the movements of the head, swallowing, etc.

He repeated the former experiment with the same results on both sides, and I again convinced myself, by testing the hearing power in the left ear, with the voice in a whisper, that after the patient had made the movement of the head above described his perception for this test was most excellent, while before that a loud voice was heard at no greater distance than 18 paces.

There was no question of dissimulation, the less so that the patient, accompanied by his brother, made a pretty long journey every time that he visited me. Moreover, nothing has as yet been said concerning a legal process with which the case was incidentally connected.

Although I doubted the presence of a movable exudation in the middle ear, certain symptoms induced me to perform paracentesis on both sides. These were : the sensation as of movement of a fluid in the ears, accompanied by marked improvement in hearing ; and the sensation of resonance, particularly on the left side.

I performed paracentesis and injected air, which passed through the openings on both sides with a hissing noise, and without the appearance of a trace of fluid, although the air-douche was used several times, and repeated a few hours later. The hearing power remained the same as before the paracentesis.

No reaction followed the operation, and the patient's condition remained in every respect the same, so that on

his departure, after a further period of four days devoted to the treatment of the pharynx, nasal passages, and Eustachian tube, we were both much dissatisfied.

The peculiarity of the case is to me inexplicable; but I nevertheless considered it my duty to report it.

In answering the question, what certain signs have we, in cases of diminished transparency of the memb. tymp. by which to establish a diagnosis of the presence of serous accumulations in the tympanum, we must admit that, under the circumstances above described, it can only be a diagnosis of probabilities, and it would be well to retain the patient under observation a few days before determining upon paracentesis; because, though it may be performed in the majority of cases without detriment, in a few of our cases we saw unfortunate consequences which we could not but trace directly to the operation. In three cases it was followed by painful purulent inflammation, which resulted in the formation of furuncles in the external meatus. Whether the rigors occurring on the first and second evenings after the paracentesis in Case II., were directly referable to the operation, is questionable. Great resistance in the Eustachian tube, and the regular bubbling râles which occur where a lesser degree of resistance permits the passage of the air, together with the immediate improvement in hearing and its subsequent decrease when the air-douche is not continued, may be taken as the most reliable guides to the diagnosis when it cannot be con-

clusively determined by the examination of the membrana tympani.

Treatment.—It may perhaps appear strange that I determined upon paracentesis in each of the seven cases, even when both sides were affected. The object was to see if it were not possible to shorten the period of treatment. Aside from the fact that this is desirable to the surgeon in all cases, it is especially to be considered when the patient comes from a distance, often of many miles. In such case a short term of treatment is particularly acceptable.

The results of these cases cannot be taken for comparison, especially when we consider the complications described in connection with them, with the exception, perhaps, of two (Cases II. and V.). In the remainder we can scarcely lay the blame either to the unfavorable circumstances by which some of the patients were surrounded, or to the prevailing cold wet weather of this summer at the time of treatment. In the chronic cases the obstinacy of the affection and the frequency of relapse were due to the long existing closure of the Eustachian tube, which often persisted during the first part of the treatment, and tended to induce a rapid reproduction of the serum—(compare Case VI.).

This occurred in Case II. (after a lapse of sixteen hours, the Eustachian tube being free, and the artificial perforation remaining open), notwithstanding the permeability of the tube, because, as a result of the persistent duration of the trouble, the congested vessels of the tym-

panum continued to retain their tendency to serous exudation for a long time. This fact indicates immediate paracentesis in recent cases. In chronic cases I should attempt in the first place to attain the desired end by use of Politzer's air-douche, with the head reclining or bent far forward.

Further concerning Politzer's air-douche. Case VI. shows that it is sometimes ineffectual (even after paracentesis), on account of the resistance in the Eustachian tube. I should perform paracentesis in chronic cases where treatment with the air-douche had been continued for some time without the desired effect. It is unconditionally indicated where the air-douche has been entirely ineffectual, because of the excessive quantity of the secretion and resistance in the Eustachian tube.

In cases when both sides are affected, it should be first performed on the one where there is the most resistance.

During the time immediately following the paracentesis we should not omit to make the patient remain in bed, or keep to his room, at least until the perforation has closed, and in unfavorable weather under all circumstances. Early treatment of the pharynx and nasal passages is necessary.

On the whole, the results are so favorable and the cure so often a permanent one, that the treatment of serous accumulations in the tympanum may be numbered among the most satisfactory in aural surgery.

ON THE MECHANISM OF THE OSSICLES OF THE EAR.

By ALBERT H. BUCK, M.D., of New York.*

In 1851 Edward Weber † put forth the doctrine that in the transmission of sound from the external ear to the acoustic nerve the ossicles play the part of a solid angular lever, whose office is to transmit to the fluid of the labyrinth the movements imparted to the *membrana tympani* by waves of sound. According to this doctrine the fluid of the labyrinth is moved only as a whole, and the function of the *membrana tympani secundaria* is simply that of affording a point where the fluid can yield to the pressure made upon it by the base of the Stirrup.

On the other hand, the prevailing doctrine was that the ossicles form a connecting medium through which waves of rarefaction and condensation are transmitted from the *membrana tympani* to the fluid of the labyrinth, and that some waves of sound also reach the labyrinth by way of the *fenestra rotunda.*

* An essay to which a prize was awarded by the Alumni Association of the College of Physicians and Surgeons of New York.

† Berichte über die Verhandlungen der K. Sächs. Gesellschaft der Wissenschaften zu Leipzig. Math. Phys. Classe, 1851.

Between these two views physiologists have been divided in opinion even up to the present time, although the majority perhaps favor the former doctrine.

In the following experiments an attempt has been made to determine by direct observation which view is the correct one. The method employed in the investigation is very simple, and free from the objections to which Politzer's method is liable.* This experimenter attached fine glass rods to different parts of the ossicles and studied their action whilst concentrated waves of sound were being conducted into the external auditory canal. As will be seen farther on, these rods constitute an important disturbing element, both by their weight and elasticity.

I am indebted to Prof. Helmholtz as well for the suggestion of this method, as for his constant assistance throughout the course of the experiments.

Material used, mode of preparing it for observation, and means employed for conducting waves of sound into the external auditory canal.

Specimen.	Age.	Sex.
Nos. 1 and 2.	30.	Male.
No. 3.	20.	Female.
Nos. 4 and 5.	50.	Male.
No. 6.	40.	Male.
No. 7.	20.	Male.
Nos. 8 and 9.	29.	Male.
Nos. 10 and 11.	29.	Male.

In the following experiments eleven human adult temporal bones were used. They were removed from the

* Archiv für Ohrenheilkunde, 1864.

bodies as soon as possible after death, and preserved in a very weak solution of spiritus vini.

A portion of the cartilaginous external auditory canal was left attached to each temporal bone, sufficient to admit of the introduction of a suitable sound-conducting tube. The roof of the drum was then carefully chiselled away until a good view could be obtained of the greater part of the hammer and anvil, and of the head of the stirrup. The labyrinth and all the connections of the membrane of the drum and ossicles, with the exception of the *ligamentum mallei superius*, were left undisturbed. As a sound-producing medium, organ-pipes were found to answer the purpose best. To connect these with the ear in such a way that the vibrations within the pipe might be conveyed with the least possible loss to the air contained in the external auditory canal, the open end of the pipe was closed with a thin board cover, and a glass tube 17 cm. long, and with a lumen of 14 mm., was firmly inserted into an opening in the centre of the board. The free end of the glass tube had been previously drawn out so as to present a lumen of 5 mm. This was made to fit tightly in the external ear by surrounding the end with sealing-wax. For light an ordinary kerosene lamp was used, the rays from which were concentrated by means of a convex lens on the spot to be observed. This had been previously dried with the end of a heated wire, and then sprinkled with powdered starch. These fine masses of starch, when examined with a low power of the microscope (24 diam.), appear-

ed as sharply defined luminous points, or, when set in rapid motion, as luminous lines. In the course of the experiments, however, it was ascertained that starch could be dispensed with, as the simple irregularity and moisture of the parts offered a sufficient number of luminous points for all purposes of observation.

Lengths of excursions on different parts of the ossicles.

The following measurements were made by means of an ocular micrometer. By turning the eye-piece round until the luminous lines ran exactly at right angles to the subdivisions of the micrometer, their lengths could then be readily measured. As far as possible they were taken from the same positions, namely, from above, as seen in Fig. 1, and from the side, as seen in Fig. 2.

With an organ-pipe of 110 *vibrations.*

Number of Specimen.	Head of Hammer from above.	Body of Anvil from above.	Head of Stirrup from above.	Head of Stirrup from side.
1	0.07 mm.	0.04 mm.	0.03 mm.	Not observed.
2	0.09 mm.	0.04 mm.	Scarcely visible.	" "
3	0.03 mm.	0.03 mm.	0.03 mm.	" "
5	0.04 mm.	0.03 mm.	Scarcely visible.	Scarcely visible.
6	0.04 mm.	0.03 mm.	" "	" "
Average =	0.05 mm.	0.03 mm.	0.01 mm.	

With an organ-pipe of 220 *vibrations.*

Number of Specimen.	Head of Hammer from above.	Body of Anvil from above.	Head of Stirrup from above.	Head of Stirrup from side.
1	0.28 mm.	0.14 mm.	0.03 mm.	Not observed.
2	0.28 mm.	0.16 mm.	0.06 mm.	0.06 mm.

3	0.12 mm.	0.07 mm.	0.03 mm.	0.04 mm.
4	0.12 mm.	0.06 mm.	0.03 mm.	0.03 mm.
5	0.06 mm.	0.03 mm.	Scarcely visible.	Scarcely visible.
6	0.09 mm.	0.05 mm.	" "	0.03 mm.
7	0.24 mm.	0.12 mm.	0.03 mm.	Not observed.
Average =	0.17 mm.	0.09 mm.	0.025 mm.	0.03 mm.

With an organ-pipe of 400 *vibrations.*

Number of Specimen.	Head of Hammer from above.	Body of Anvil from above.	Head of Stirrup from above.	Head of Stirrup from side.
1	0.28 mm.	0.12 mm.	0.06 mm.	Not observed.
2	0.21 mm.	0.12 mm.	0.06 mm.	" "
3	0.21 mm.	0.12 mm.	0.06 mm.	0.07 mm.
4	0.19 mm.	0.09 mm.	0.03 mm.	0.04 mm.
6	0.21 mm.	0.09 mm.	0.03 mm.	0.03 mm.
7	0.21 mm.	0.12 mm.	0.04 mm.	0.04 mm.
8	0.09 mm.	0.06 mm.	0.04 mm.	Not observed.
9	0.31 mm.	0.24 mm.	0.12 mm.	0.31 mm.
10	0.31 mm.	0.16 mm.	0.03 mm.	Not observed.
11	0.31 mm.	0.16 mm.	0.01 mm.	" "
Average =	0.23 mm.	0.128 mm.	*0.048 mm.	0.09 mm.

With an organ-pipe of 600 *vibrations.*

Number of Specimen.	Head of Hammer from above.	Body of Anvil from above.	Head of Stirrup from above.	Head of Stirrup from side.
1	0.09 mm.	0.04 mm.	0.01 mm.	Not observed.
2	0.07 mm.	0.04 mm.	0.01 mm.	" "
3	0.07 mm.	0.04 mm.	0.03 mm.	" "
4	0.06 mm.	0.03 mm.	Scarcely visible.	" "
Average =	0.07 mm.	0.037 mm.	0.012 mm.	

* By compressing the air in the external auditory canal and measuring the displacement in a column of mercury connected with the superior semi-circular canal, Helmholtz estimated the length of an excursion of the base of the stirrup at 0.05 + mm.—*Mech. der Gehörknöchelchen, etc.*, 1869.)

Direction of luminous lines on different parts of the ossicles.

As observed from above, the luminous lines on the heads of the hammer and anvil appeared slightly divergent outwards (see Fig. 1). This divergence was found to be the same on all the specimens. As observed from the side, in a direction at right angles to the long axis of the hammer, they presented the following appearance:

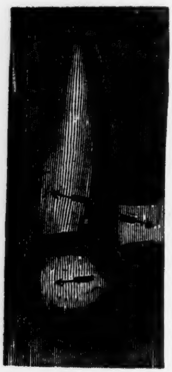


Fig. 1.

—On the hammer the luminous lines appeared to be arcs of circles whose common centre lay in the immediate neighborhood of the *Processus Folianus* (see Fig. 2). On two of the specimens it was noticed that the luminous lines, measured at the very end of the handle of the hammer, were 0.43 mm. and 0.38 mm., whilst those measured at the head were 0.31 mm.; in other words, that in these instances, at least, the axis of rotation did not pass through the middle of the ossicle, but somewhat above it. On the anvil the luminous lines followed the direction marked in Fig. 2. On the lower part of the long process they seemed to be nearly or quite vertical, but on approaching the body of the bone they became more oblique. Owing to the enclosed position of the anvil, it was not found practicable to obtain an observation from the side higher up than the one marked in Fig. 2. On four specimens the relative measurements

on the body (seen from above) and the long process (seen from the side) of the anvil were as follows:—

Number of Specimen.	Body.	Long Process.
8	*2	1½
9	8	10
10	5	2
11	5	3

They are of interest, as helping to indicate the position of the axis of rotation of this ossicle. In specimens No. 8, No. 10, and No. 11, the hammer and anvil were joined together in the ordinary manner as represented in Fig. 3, whilst in specimen No. 9 the anvil was more inclined inwards (see Fig. 4). In Fig. 3 (drawn from specimen No. 10) the luminous lines are arcs of circles whose common centre is at A. The top of the body of the anvil being twice as far from this centre as the end of its long process, its excursion is twice as great In Fig. 4 (drawn from specimen No. 9) the different lengths of excursion can only be explained by supposing the axis of rotation to be placed nearer the body of the ossicle (as at A′). As observed from

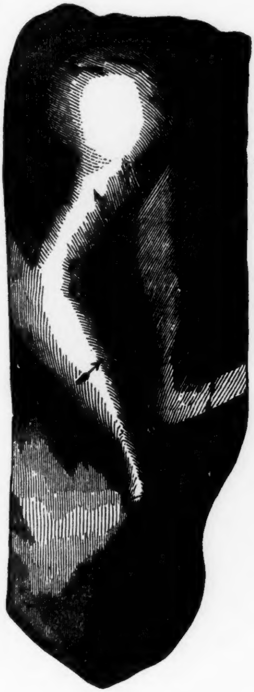


Fig 2.

* Number of micrometer subdivisions.

above, the luminous lines on the stirrup appeared in the majority of cases to be directed nearly, though not

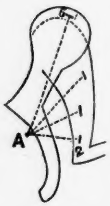


FIG. 3.

quite, at right angles to its base. In only two cases was it found possible to obtain a view of both arms of the stirrup at once. In one of these cases the luminous lines were directed at right angles to the base (see Fig. 5), while in the other they ran somewhat obliquely toward it. The inclination in all cases was toward the anterior extremity of the base (see Fig. 6).

Viewed from the side, the luminous lines on the stirrup were in all instances directed obliquely upwards and inwards across the head and anterior arm (see Fig. 2).

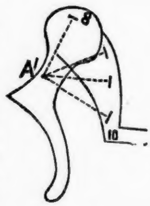


FIG. 4.

In spec. No. 6 the upper and inner wall of the vestibule was carefully chiselled away, so as to present an inner view of the base of the stirrup. When it was put in vibration the luminous lines on the upper border of the base measured 0.03 mm., and were vertical, but on the lower border there was not sufficient motion to admit of measurement.

Fenestra Rotunda.

Enough of the lower wall of the drum was removed in specimen No. 1 to admit of a good view of the *membrana tympani secundaria.* The moment the organ-pipe was sounded the bright spot in the centre of the mem-

brane lengthened out into a distinct luminous line of 0.04 mm. On the head of the stirrup, as seen from above, the luminous lines measured only 0.03 mm. The superficial area of the *fenestra rotunda* being smaller than that of the base of the stirrup, a greater excursion might rightly be expected from the membrane of the former. In the present case the membrane was observed obliquely from the side and not directly in profile, so to speak; hence the measurement would represent only a portion of the true length of the excursion. The measurements on different parts of the ossicles, before and after breaking up the membrane, were the same.

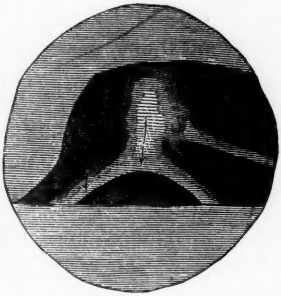


FIG. 5.

The influence of the different ligaments.

Tendons of the *tensor tympani* and *stapedius*. The measurements immediately before and after the division of these tendons (considered as ligaments) were precisely the same, and no difference could be observed in the direction of the luminous lines on the stirrup after the division of the tendon of the *stapedius*.

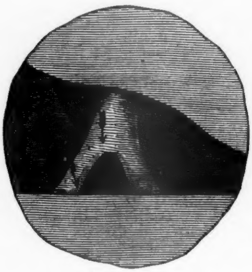


FIG. 6.

The modifications produced by attaching fine glass rods to the hammer and anvil.

A fine glass rod, of about the thickness of a fine bristle, and 5 cm. long, was glued in an upright position to the head of the hammer. Before doing this the measurements with an organ-pipe of 400 vibrations were:

Head of hammer = 0.31 mm.
Body of anvil = 0.16 mm.

Afterwards they were found to be:

Head of hammer = 0.12 mm.
Body of anvil = 0.06 mm.

Cutting off 1 cm. from the end of the rod, the measurements were:

Head of hammer = 0.16 mm.
Body of anvil = 0.09 mm.

Cutting off 2 cm. they were:

Head of hammer = 0.16 mm.
Body of anvil = 0.09 mm.

Cutting off 3 cm. they were:

Head of hammer = 0.18 mm.
Body of anvil = 0.10 mm.

Cutting off 4 cm. the measurements remained the same. Leaving nothing but the small drop of glue, the measurements were:

Head of hammer = 0.24 mm.
Body of anvil = 0.12 mm.

After removing the glue from the head of the hammer and fastening a glass rod 5 cm. long and of the same thickness as the preceding to the body of the anvil,

the measurements with an organ-pipe of 400 vibrations were:

Head of hammer = 0.31 mm.
Body of anvil = 0.12 mm.

Cutting off 1 cm. they were:

Head of hammer = 0.31 mm.
Body of anvil = 0.13 mm.

Cutting off 2 cm. the measurements remained the same.
Cutting off 3 cm. they were:

Head of hammer = 0.31 mm.
Body of anvil = 0.16 mm.

These experiments would show that the method of using glass rods to determine the character of the vibrations of the ossicles is not trustworthy. Even a drop of glue, the size of a pin's head, attached to the head of the hammer was sufficient to reduce its excursion 0.07 mm. On the anvil the disturbing influence of a weight or rod was much less than on the hammer.

Anatomical study of the manner of attachment of the Stirrup to the Fenestra Ovalis.

After having determined the direction in which the stirrup vibrates, the question presented itself, whether its base were not attached to the *fenestra ovalis* in a manner specially adapted to this mode of vibration. Works on anatomy give such meagre and conflicting information on this point that it was thought necessary to investigate it more thoroughly. The method employed

was suggested by Prof. Julius Arnold, under whose kind supervision the investigation was made.

The stirrup, together with the mass of bone immediately surrounding it, was first removed from the temporal bones of new-born children and adults as soon as possible after death, and in such a manner as to obtain this ossicle with all its attachments to the *fenestra ovalis* uninjured. These specimens were placed in three ounces of a 1% solution of chromic acid, the solution being renewed every fourth day after. At the end of a month a 2% solution was used. Two weeks later, two of the specimens were soft enough to be cut with the razor. The others remained a week longer in a 2% solution, to which three drops of concentrated hydrochloric acid had been added. From these solutions of chromic acid the specimens were transferred to alcohol, and, when sufficiently hardened, they were imbedded in paraffine. Fine sections were now made with the razor in both horizontal and vertical directions. In order to make the sections exactly parallel with the two axes of the base (the long or nearly horizontal, and the short or nearly vertical) the paraffine was carefully removed from the vestibular side of the stirrup, so as to expose only its base to view, whilst all the rest of the bone remained firmly imbedded in it. As some of the horizontal sections included the *musculus stapedius*, the anterior and posterior parts were easily determined. In the vertical sections the presence of the *tensor tympani* afforded the same assistance in locating the upper and lower parts.

In the study of these horizontal and vertical sections the base of the stirrup is found to be attached to the *fenestra ovalis* by a circular band of uniform strength throughout. Its fibres run in a convergent direction from the margin of the *fenestra* to the opposite margin of the base of the stirrup. In their course they cross each other at very acute angles. They are rich in oval nuclei, and are separated only by a slight quantity of an homogeneous, but dense intercellular substance. The periosteal covering of the bone in the immediate neighborhood of the *fenestra ovalis* is continuous with this circular band, or, in other words, the tympanic and vestibular layers of periosteum unite at the margin of the *fenestra,* then run together as one band as far as to the margin of the base of the stirrup, where they subdivide to take the base between their folds, and serve it in the capacity of periosteal covering.

On the outer side the band is covered everywhere with the mucous membrane of the drum, which was found here to be rich in blood-vessels of various sizes. In many of the horizontal and vertical sections, cross-sections were found of large arteries at the very edge of the *fenestra,* or even directly in front of the band. These sent off smaller branches that pierced the band in various directions.

On the inner side the band is also covered with an epithelial layer, which is, however, much thinner than the outer one.

In adults the bone forming the *fenestra ovalis* differs

in nowise from ordinary bony tissue, except that at the periphery, immediately beneath the periosteum, there is always found a thin layer of cartilage-like tissue, consisting of ovoidal and spindle-shaped cells and an homogeneous intercellular substance (periosteal cartilage). The same tissue is also found at the periphery of the bone in children, and moreover, in the very substance of the bone small cartilaginous islands are often seen.

The base of the stirrup is likewise formed of true bone, at the periphery of which there is found a thin layer of periosteal cartilage immediately beneath the periosteum, and intimately united with it. In adults the base was found to be thicker at the two ends than in the centre; the two ends were, however, very nearly alike in thickness. In children the posterior end was found to be thick and quadrangular, whilst the anterior was narrow and rounded (see accompanying plate). The layer of cartilage beneath the vestibular periosteum was found, moreover, to be much thicker than in the adult.

It is necessary to state here that unless the sections are either parallel or at right angles to the long axis of the base, they will totally misrepresent the true relations of the parts. For instance, among a number of vertical sections cut from the same specimen, I obtained three entirely different views: one where the lower border appeared somewhat flattened, whilst the upper was smaller and more pointed; a second, where the reverse was found to be the case; and a third, where both ends appeared alike. The breadth of the circular band varied

also, according to the direction in which the section was made.

To state briefly the results of this anatomical study: (1) The stirrup is attached to the *fenestra ovalis* by means of a circular band composed of elastic tissue; (2) The fibres of this band run from the margin of the *fenestra* to the base of the stirrup in a convergent direction; (3) The band is formed of the layers of periosteum covering the bone in the immediate neighborhood of the fenestra, and on reaching the base of the stirrup it again resumes its function of periosteum; (4) The band is everywhere of equal breadth.

From the preceding experiments two conclusions are arrived at: (1) That the bones of the ear vibrate as a whole; and (2) That with each vibration there is a corresponding displacement of the fluid of the labyrinth.* This is precisely the doctrine held by Weber twenty years ago. It also appeared that with each wave of sound the membrane of the drum is driven inwards a certain distance and then returns to its original position, so that the end of the handle of the hammer, which is imbedded in the substance of the membrane of the

* Politzer first proved experimentally that the ossicles vibrate as a whole (Archiv für Ohrenheilkunde, 1864). The chief question of dispute had been concerning the movement of the fluid of the labyrinth as a whole. Politzer and Helmholtz sided with Weber, whilst Henke and Schmiedekam held the contrary view.

drum, makes an excursion to and fro of equal length, and the length of such an excursion may amount to 0.43 mm. without any appreciable injury to the parts. But if one places the glass tube of the organ-pipe in his own ear the shock produced on the membrane of the drum is felt to be too painful to be borne for any length of time, so that the ordinary excursion of the membrane of the drum during life would seem to be much less than this measurement. The axis of rotation of the hammer lies nearly midway between its two extremities, so that when the end of the handle is driven inwards the head makes an equal excursion outwards. The particles forming the upper part of the head of the hammer move very nearly horizontally outwards, whilst those near the lower margin of the *malleo-incudal* joint move upwards as much as outwards. Helmholtz has shown that the hammer and anvil are united by a joint which in principle resembles that used in watch-keys, where the head of the key can be made to rotate in one direction without carrying the body with it, whilst in the opposite direction the body must necessarily follow. The lower tooth of the incudal half of the joint fits into a depression on the inner side of the hammer, just where the particles forming that part vibrate in an upward and outward direction. From an observation of the luminous lines on different parts of the anvil it was found that in fact such an upward and outward motion is communicated to this ossicle.

But in addition to this motion the body of the anvil

is thrown slightly backwards, or, in other words, the end of its long process is thrown forwards, as if the axis of rotation ran from the end of the shorter process of the anvil forwards, downwards, and outwards through the *processus brevis* of the hammer.

The head of the stirrup being joined to the end of the long process of the anvil by a fully formed capsular joint, it is obliged to follow to a great extent the direction taken by the end of the long process of the anvil, namely, upwards, slightly inwards, and forwards. As a result of this, the upper and anterior border of the base of the stirrup is driven farther into the vestibule than the lower and posterior border; * in other words, its axis of rotation runs either through the lower border of the margin of the *fenestra ovalis*, or a little below and parallel to it. Hence a displacement of the entire mass of the fluid of the labyrinth takes place, and in no other manner can the vibrations observed on the *membrana tympani secundaria* be explained.

The average measurements show that an impulse given to the centre of the drum is communicated from ossicle to ossicle with a loss in the following ratio:—

Hammer	=	4
Anvil	=	2
Stirrup	=	1

In two cases (see first table of measurements) where the

* By a somewhat different method of investigation Helmholtz determined the axis of rotation of the stirrup. The above result confirms his description in its essential points.

membrane of the drum was caused to vibrate feebly, scarcely any loss took place in the transmission of the impulse from the hammer to the stirrup. Taking into consideration, moreover, that all these measurements may be looked upon as representing rather the maximal than the ordinary excursions of the ossicles, it may well be doubted whether during life the loss in transmission be not much smaller than that given above.

HISTORICAL AND CRITICAL REMARKS CONCERNING THE DEAFNESS FOLLOWING MENINGITIS CEREBRO-SPINALIS.

By S. MOOS, M.D.

Translated by Dr. Joseph Aub, of Cincinnati.

In Nro. 1 of the "Monatsschrift für Ohrenheilkunde," Voltolini, in a paper describing a new disease discovered by him, and titled "The acute inflammation of the membranous Labyrinth, commonly but erroneously considered as Meningitis," takes occasion to criticise the remarks made in my "Klinik der Ohrenkrankheiten," on the deafness occurring so frequently after meningitis. He believes that the thirteen cases observed by me were all primary acute inflammations of the labyrinth. Voltolini does not even acknowledge the possibility of their being secondary diseases of the labyrinth, occasioned by a propagation of the meningitis. The reasons which he alleges to corroborate his doubts on the correctness of my statements are the following, among others:—

The want of all paralytic symptoms, especially in the region supplied by the facial nerve, speaks against a meningitis with exudation at the auditory nerve. Vol-

tolini asserts that he has never noticed a trace of facial paralysis, and asks, "How is this possible when there is exudation in the auditory nerves? This is utterly inconceivable." He then sums up the anatomical reasons why this appears inconceivable to him.

Experience shows, however, that what may appear inconceivable to some is nevertheless possible, and of actual occurrence. Voltolini might easily have gathered some information on the subject in reading my discussion of the affection (p. 324, l. c.), had he only not omitted to peruse my quotations from *Niemeyer's* Monograph on epidemic cerebro-spinal meningitis, where the following is emphatically expressed:—

"Hardness of hearing, up to complete deafness, sometimes in one ear, sometimes in both, has been noticed in comparatively many cases. Occasionally it manifests itself early, at other times during the further progress of the affection, and may, when the primary disease is protracted, continue for weeks, and even for months, as I have shown in a case mentioned above. It may even outlast the primary disease in cases ending in recovery.

"I do not consider it improbable that the deafness and hardness of hearing may be produced by different causes. In the pathological specimen examined by myself in connection with Prof. *Luschka*, and which Dr. *Riedel* had the kindness to send me to Tübingen,—consisting of the pons, cerebellum, medulla oblongata, and portion of the spinal column of J. Schwarz,—we found the acoustic nerve, up to its exit from the skull, so completely em-

bedded in masses of exudation, that Prof. Luschka felt justified in supposing that the inflammation and exudation following the course of the nerves might easily, in some cases, extend into the labyrinth, and thus produce deafness. We could readily corroborate in the same specimen the fact that the exudation extended from the base of the brain, through the hiatus Magendii (described by Luschka, and lately denied and declared artificial by *Reichert*), into the fourth ventricle, and there principally covered the striæ acusticæ. Adding to this the fact that the immersion of the acoustic nerve in exudative masses alone may produce deafness, we cannot be astonished at the frequency of this symptom in the epidemic cerebro-spinal meningitis." This passage seems to have entirely escaped the attention of Voltolini.

Since then a number of facts have been published which demonstrate that deafness is not an accidental but a remarkably frequent symptom of, or an affection consequent on, cerebro-spinal meningitis. Refer:—

1. Report on those persons in the Bavarian army who received medical treatment during the first half of the year 1865; published in the Baierischen aerztlichen Intelligenzblatt, Nro. 52, 1865.

2. Dr. *Gustav Ohlsen.* Beitrag zur *Cerebrospinal-Meningitis.* Wuerzburg, 1866.

3. *Ziemssen* and *Hess.* Deutsch. Archiv fuer Klin. Med., I., 1, 3, 4. 1865.

4. Dr. Fluegel. Bayer. Intelligenz. Nro. 50. 1865. The epidemic cerebro-spinal meningitis in the district Naila.

Among about 300 cases, 5 remained deaf, 6 hard of hearing, 5 deaf-mutes, 1 deaf and blind, 3 deaf and unable to walk, and 1 blind in one eye. Total, 21 consequent diseases, or, as he calls it there, "meningitic cripples," were observed.

5. Dr. *Schweizzer*. The epidemic cerebro-spinal meningitis in the district Kronach during the year 1865. Wuerzburg, 1866. Among 115 cases during this epidemic, the most frequent sequelæ consisted in derangements of hearing, which were not only the result of a central cause, but also of a local disease of the middle ear *

6. Dr. *Orth*, on *Meningitis cerebro-spin. epid.* in the Rhein Palatinate, in the first half of the year 1865. (*Inaug. Dissertat.* Wuerzburg, 1866.) Deafness was observed twice, and strabismus three times, as among the sequelæ, in 53 cases.

7. Dr. *Bauer*. Report of 109 cases in the "Archiv des Vereins fuer Wissenschaftliche Heilkunde," III., 1, p. 173. Hallucinations of hearing were always present; complete deafness in 7 cases of recovery, and in 6 of death. Epidemic of Kentershausen and vicinity.

8. Monograph on epidemic cerebro-spinal meningitis by Prof. *Mannkopf*, M.D. Brunswick, 1866. Among 16 cases he observed, 4 presented disturbances of hearing.

9. *A. Heller*. The anatomical changes leading to dis-

* Such post-mortem observations, especially purulent inflammations of the middle ear, were first described by *Klebs;* we have mentioned them (l. c. p. 326).

turbances of hearing in *cerebro-spinal meningitis.* Deutsch. Archiv fuer Klin. Med., III., p. 482.

The two following observations relating to our subject are taken from a series of cases which occurred during a wide-spread epidemic:—

CASE I.—Purulent cerebro-spinal meningitis. Fresh hemorrhagic, and numerous encephalitic foci in the brain. Croupous pneumonia of the left side, splenic tumor, diffused swelling of the kidneys. In both tympanic cavities much pus. In the vestibules numerous pus-cells, a larger quantity in the ampullæ; the cochleæ were very red, and filled with pus-cells. The vessels of the membranous portion of the lamina spiralis are much injected; its peripheral half is filled with pus, the inner half of its surface less so. *NN. acust.* and *facialis* of both sides surrounded by pus in the *meat. audit. int.* On microscopical examination very few pus-cells were found between the fibres of the facialis, whilst those of the acusticus and its ganglion cells are densely surrounded by them. In both nerves the fibres are well preserved, the vessels filled to bursting, and their walls thickened.

CASE II.—Woman, aged forty-five. Disease of the brain and pneumonia. Post-mortem examination:—Purulent *meningitis cerebro-spinalis*, etc. The organs of hearing present about the same changes as the first case; in addition, dotted ecchymoses in the peripheral portion of the lamina spiralis.

We see therefore that purulent inflammations in the

inner ear and tympanic cavity may accompany the disease in question. We have to deal with a well marked inflammation of the labyrinth. This may occur simultaneously with the changes in the meninges of the brain and spinal column, or, following the course of the neurilemma, it may advance into the labyrinth.

Finally, I would add that the co-editor of these Archives assured me that during his stay in Heidelberg he observed about forty cases of diseases of the eye, mostly purulent choroiditis, consequent on cerebrospinal meningitis.

Of all these cases only one, which I afterwards examined, suffered from deafness, and yet the report of the attending physicians and the examination of the patients showed that disease which, according to Voltolini, is not meningitis, but "independent acute inflammation of the membranous labyrinth." It would be carrying coals to Newcastle to enter into further discussion on this subject; I will therefore pass over the other arguments of Voltolini, which contain nothing new; for instance, that children with *otitis media purulenta* often manifest cerebral symptoms, or that a staggering gait, and even vomiting, are also met with in other ear diseases, etc., etc.; for I, as well as other physicians, have seen the disease not only in children (on which fact Voltolini lays great stress), but also in adults, and have indeed published (p. 327, l. c.) the precise history of the case of a girl of seventeen, in which the diagnosis was no more doubtful than in the case published in the first number

of these Archives. Nor have I declared the staggering gait as pathognomonic, but only mentioned it among the sequelæ of this disease.

In conclusion:—In view of the above clinical observations, and the pathologico-anatomical facts, no one will doubt the frequent occurrence of a nervous deafness which may accompany, or be the result of *meningitis cerebro-spinalis epidemica*, and I think that even Voltolini is now of the same opinion. We only hope that he may very soon succeed in proving by a post-mortem observation that the disease described by him as "the acute inflammation of the membranous labyrinth" is an independent affection.

SUDDEN HEMORRHAGE INTO THE RIGHT TYMPANUM ACCOMPANYING ANGINA DIPHTHERITICA—PROTRACTED RECOVERY.

By Prof. S. MOOS.

Translated by C. J. Blake, M.D., Boston.

The following case was observed in the daughter of a colleague by whom I was called in consultation, and to whom I am indebted for the history:—

Miss H. A., 17 years old, previously in perfect health, was attacked on the 9th of April, 1868, with general symptoms of fever, which increased on the following day, accompanied by the formation of diphtheritic deposits, first upon the left and then upon the right tonsil.

Within a few days the exudation extended over the tonsils, which were much enlarged, and implicated a portion of the uvula. The glands of the neck, especially upon the right side, where the tonsil was most affected, became swollen, and the movement of the lower jaw was rendered difficult and painful. Following the internal administration of kali chloric. and a mild gargle, the throat rapidly became clean, the fever and accompanying troubles diminished, and at the end of a week, dating from the time of the attack, the patient was free from fever, and remained so for several days.

On the night of the 21st and 22d of April, without any apparent

cause, the trouble returned, accompanied by active fever. The right tonsil became covered with new exudation, which in this case affected the inner surface more especially, and obviously extended backwards and upwards. It being impossible to introduce the rhinoscope, this fact was inferred from the increased difficulty in moving the jaw, the acute pains radiating outwards from the course of the Eustachian tube, and the impermeability of the right nostril. The hearing power on the right side was also diminished, and singing sounds in the ear occurred from time to time.

In addition to the superficial exudation there was a decided diphtheritic infiltration of the tonsils.

On the 23d of April, the urine, hitherto clear and secreted in small quantity, showed the presence of albumen,—at first nearly a third of the volume of the specimen examined. This decreased, however, on the exhibition of decoct. fruct. colocynth., so that on the 28th the urine was free from albumen and continued to be secreted in larger quantity. During this period frequent vomiting occurred, and the local as well as general troubles were very marked. The following is the daily record of the pulse and temperature (*Celsius*) for the above period:—

	TEMPERATURE.		PULSE.	
	A.M.	P.M.	A.M.	P.M.
April 24.........	39.0	39.1	96	104
" 25.........	39.2	39.6	97	108
" 26.........	38.4	38.9	96	112
" 27.........	37.9	38.5	84	92
" 28.........	37.8	37.9	80	84
" 29.........	37.0	37.2	72	77

From the commencement of the relapse ungt. hydr. cin. and cataplasms were freely used, and aq. calcis inhaled by means of the atomizer. For several days from the 29th of April the temperature and pulse remained about the same; the nasal tone of the voice and the difficulty in swallowing—due to the swollen condition of the affected parts—were but little diminished, although examination failed to detect the

presence of diphtheritic exudation. On the whole, considering the severe symptoms of the past few days, the condition of the patient gave promise of continued improvement.

On the 2d of May, at about 6 A.M., after a quiet night, there was a sudden severe hemorrhage from the right nostril and throat, originating from the posterior surface of the right tonsil and vicinity, allayed by the application of dilute vinegar by means of Weber's nasal douche, and the application of ice-bags accompanied by the internal exhibition of ice.

The patient, who was considered reconvalescent, was greatly reduced by this accident. Speaking and swallowing, however, were very much easier from this time.

Symptoms of fever again appeared; the accompanying increase of temperature but slightly exceeded 38° C. however, and, together with the reappearance of albumen in the urine, continued till May 9th, when the pulse again fell to 72, and the temperature decreased to 36.9. From this date the patient convalesced rapidly, so that on the 21st of May she was able to drive out for the first time. She was able to remain out of bed for a long time every day, the appetite and strength increased, and there was but one thing to be seriously regretted : there was renewed difficulty in swallowing, in so great a degree that food could be taken only in a recumbent position and very slowly swallowed, a result of the occurrence of partial paralysis of the right velum palatinum (the posterior pillæ being drawn backwards).

On the morning of the 30th of May serious symptoms suddenly reoccurred. For the first time during her illness there was a severe attack of sneezing, followed by acute pain in the right ear, extending over a portion of the right side of the face. In hope of finding relief, the patient lay upon a sofa and pressed the right side of the face upon a pillow for the sake of warmth. The pain, however, increased every moment and extended over the whole side and down into the neck. About an hour later an examination was made.

The palate exhibited a slight line of coagulated blood, which was attached to the right velum; beyond this there was no change in appearance. The pain extended over the right side of the face, neck, and

throat, and was described by the patient, who had heretofore shown great fortitude, as being most intense. The hearing power in the right ear was reduced to a minimum.

Examination with the speculum showed the membrana tympani to be uninjured, of a brownish-red color, and pressed outwards, rendering it convex. The patient was immediately placed upon the left side and ice applied to the right side. The pain thereupon gradually diminished, and she thought she heard crackling noises, and occasionally a "trickling downwards within the ear," which latter sensation could not be explained by examination; towards evening the pain had ceased, but an examination of the membrana tympani showed no change.

The following morning (May 31st) the upper third of the membrana tympani was decidedly paler, while the lower two-thirds were still of a reddish-brown color.

There were some subjective noises, the hearing was improved, but was still far below the normal standard.

During the next few days the abnormal coloring of the memb. tympani gradually diminished.

On the 4th of June Prof. Moos had the kindness to examine the patient. The hearing distance for a moderately loud voice was seven paces, for the watch (six feet normal distance), five inches. The tuning-fork placed upon the head was heard only upon the right side. The memb. tympani appeared of a light brown color, with diminished light spot, but without substantial abnormality in curve. The manubrium was plainly visible. Swallowing with closed mouth and nostrils produced no change. Under the circumstances paracentesis was not admissible, but the air-douche was employed with good results. The subjective noises were only occasional, and soon disappeared entirely. The hearing power became normal, but the right ear remained for some time exceedingly sensitive to loud tones and sounds. It was a long time also before the power of swallowing was perfect. A stay of several weeks upon the Rigi contributed much to a perfect recovery.

The diphtheria was in all probability accompanied by a hyperæmic condition of the mucous membrane of the Eustachian tube and tympanum, originating at the time of the second attack (21st, 22d), at which time decrease in the hearing power and occasional subjective noises appeared.

The severe attack of sneezing, occurring on the morning of the 30th of May, may be taken as the circumstantial cause of the sudden hemorrhage. A true diphtheritic affection of the tympanum, occurring in the way of simple mechanical transplantation, is less probable: the pain in the ear would have been of longer duration, and there would probably have been a perforation of the memb. tympani.

Bartel describes such cases in his observations upon the Häutige Bräune (Deutsches Archiv für Klin. Medicin, Vol. II., No. 445, p. 384).

The hemorrhage was probably increased by the attempt on the part of the patient to gain warmth and relief by turning the right side of the face downwards and pressing it into the pillow. Whether the severe sneezing caused the rupture of the hyperæmic blood-vessels by simple shock, or by sudden condensation of the air in the tympanum, remains an open question.

The latter—rupture from condensation of air in the tympanum—is less likely, because in such cases, as in hooping cough, there is also generally a rupture of the memb. tympani. The severity of the pain, and its ex-

tent as above described, is by no means strange, when we consider that the hemorrhage occurred suddenly, into a space so rich in nerves as the tympanum.

Whether the sensation of "something trickling down within the ear" corresponded to the exit of the blood from the tympanum, I leave without remark.

A CASE OF IDIOPATHIC DIPHTHERIA OF THE EXTERNAL MEATUS.

By S. MOOS.

Translated by C. J. Blake, M.D., Boston.

The expectation of being able to report several cases of primary diphtheria of the external meatus induced me to defer the publication of the following case, which I had observed as long ago as August, 1865.

This expectation is as yet unfulfilled. This publication may possibly, by drawing the attention of practising physicians to this apparently rare affection, enlarge the record of such cases. Among otologists, Wreden is so far the only one who has made any observations in relation to it.

Carl Bauschliger, son of a jailer in Heidelberg, ten years old, was repeatedly under my care for purulent catarrh of the middle ear, left side, the first time on July 24th, 1864. On the 20th of November, 1864, he was discharged from the first period of treatment with a cicatrix in the anterior inferior segment. Shortly after he was attacked with the measles, which was accompanied by an acute inflammation of the tympanum on the left side, with perforation of the cicatrix, and otorrhœa.

The treatment on this occasion lasted from the 29th of January to the 19th of March, 1865. The otorrhœa ceased, but there remained a perforation in the anterior inferior segment.

On the 18th of August, 1865, he was again affected with trouble of the ear. His mother stated that since mid-day of the day but one before, he had constantly complained of pain in the left ear, rapidly increasing in severity and lasting day and night. In addition, there had been fever at the commencement of the attack, loss of appetite, excessive thirst, and during the last night even delirium.

There was no difficulty in swallowing, but mastication was impossible. The boy, who had never looked remarkably well, was very pale and exhausted, with a weak pulse, 108 in a minute, and furred tongue; the palate, tonsils, etc., were, however, clean. Traction upon the auricle and pressure about the tragus caused much pain; the same with the swollen glandulæ concatenatæ on the left side. The inner surface of the concha was of a bright red color.

The posterior surface of the tragus, the regio intertragica, and the whole surface about the outer end of the meatus, the inner portion of which could not be examined on account of the degree of contraction, were covered with a rather thick, inflexible, lardaceous, greasy coating. It could not be raised from the underlying structure: the attempt at separation resulted only in tearing the parts matted together, which was attended with bleeding and expression of severe pain on the part of the patient. With the exception of the conduction through the bones, the hearing power was almost entirely lost on the affected side.

There was no positive otorrhœa, but the ear had a very offensive odor. The affected parts were pencilled daily with argentum nitricum (gr. 15 ad ℥j.), and frequently washed with lukewarm water, and for the relief of the pain cold applications of Goulard's solution (1 to 3) were employed with good effect. On account of the pain attendant upon mastication, only fluid food—at first milk and later strong broth—was allowed. Exception was taken to local bloodletting on account of the poorly nourished condition of the patient. There was still fever, loss of appetite, and restlessness at night.

On the night of the 26th and 27th he was able to sleep.

On the 27th the coating about the tragus and entrance of the meatus commenced to peel off, accompanied by slight suppuration and considerable hemorrhage.

On the 29th of August exfoliation commenced in the meatus, accompanied by increased hemorrhage. There was now for the first time a decided decrease in the pain, syringing having been followed by a pretty considerable hemorrhage.

On the night of the 2d and 3d of September there was a repetition of the bleeding from the left ear, but without pain.

On the morning of the 3d of September the patient was free from fever and had increased appetite.

The hearing distance was five inches for a watch of six feet hearing distance, and eight paces for the voice; and there was but a slight degree of tenderness of the ear on traction or pressure. The spots upon the outside of the tragus, etc., as described, now showed a sharply marked edge with a slightly granulating and suppurating surface; the external meatus presented the same appearance; the swelling had decreased, and a speculum could be easily introduced. After syringing, which was accompanied by a very disagreeable odor, the defect in the anterior inferior segment of the membrana tympani already described could be plainly seen; the rest of the membrane was covered with pus and of a grayish-red color; the membrane was not plainly visible, but the condition which had been expected, from that of the external meatus, could not be determined, either on the membrana tympani or beyond it in the tympanum, even after repeated syringings.

From this date the affection of the external meatus rapidly improved, but the purulent catarrh of the middle ear again grew worse, so that the patient remained under treatment till the 22d of October, when he was discharged in the same condition as on the 19th of March, 1865.

In support of the diagnosis, that in the preceding case there was really a diphtheritic process in the exter-

nal meatus, but few of the symptoms presented can be considered as characteristic.

Of the affections of the external meatus which have been clinically observed, the otitis acuta diffusa externa only can be admitted to consideration. In this affection fever, gastric symptoms, pain—increasing till it is almost unbearable, and rendering mastication difficult—and diminution of hearing, may also be present. Such severe cases, however, generally only occur as the result of excessive external influences, which were wanting in this case. On the other hand, the objective symptoms are very different. An examination at the commencement of otitis acuta diffusa externa shows the meatus to be dry, swollen, and slightly reddened. The congestion rapidly increases, the moistened layer of epidermis becomes loosened, and is followed by an excessive exfoliation of epithelium, which either plugs up the meatus or comes away in shreds, sometimes in a mass, like the finger of a glove, or—as is generally the case—there is an excessive muco-purulent secretion, which leaves the cutis of a flesh-red color and bleeding freely. The secretion is readily removed by syringing.

Of the objective symptoms above described which may be considered as characteristic, are, the inflexible lardaceous exudation, firmly attached to the subjacent parts, and remaining for several days, its exfoliation followed by a greater or less degree of hemorrhage. Exfoliation of epithelium or positive otorrhœa does not appear before the separation of the exudation.

The negative results on examination of the throat, the appearance of the membrana tympani, and the condition of the tympanum, so far as it could be determined through the perforation, hardly leave room for a doubt but that *this was a case of primary diphtheritic affection of the external meatus.*

Wreden has observed five cases of Diphtheria of the ear, and in those most carefully noted the membrana tympani was implicated. (Compare Monatsschrift für Ohrenheilk., Jahrgang II., No. 10.) In our case the change in the membrana tympani must be referred to the previous affection. The purulent catarrh which had existed for some time, and which required a still further course of treatment, was evidently renewed by the later disease.

CYSTICERCUS INTRA-OCULARIS.

By Dr. J. HIRSCHBERG, of BERLIN.

Translated by Dr. Joseph Aub.

It is a well-known fact that in its earliest stage the recognition of a cysticercus* situated in the background of the eye—whether under the retina or in the vitreous body—in the great majority of the cases is a pretty easy matter, and since it is based upon direct observation with the ophthalmoscope it is also absolutely certain. During the further growth of the entozoon, and the increase of the peculiar opacities of the vitreous body caused by its presence, the diagnosis becomes more difficult;† and finally, the direct observation becomes altogether impossible, on account of the increasing dimness

* *A. v. Graefe*, Arch. f. Ophth., I., 1, 453, etc. I., 2, 326. II., 1, 259. II., 2, 334. III., 2, 308. IV., 2, 171. VII., 2, 48. X., 1, 205; and especially XII., 2, 174–198. *Liebreich*, ibidem, I., 2, 343, and Atlas of Ophthalmoscopy, p. 18 and Plate VII. *Schweigger*, Lectures on the Ophthalmoscope, p. 59, and Arch. f. Ophth., VII., 2, 53. *Mauthner & Becker* in the former's book on Ophthalmoscopy, p. 461; and *O. Becker*, Journal of the Physicians of Vienna, 1865, 385. *Busch*, Arch. f. Ophth., IV., 2, 99. *Nagel*, ibid., V., 2,183. *Jacobson*, ibid., XI., 2, 147; and others.

† *A. v. Graefe*, Arch. f. Ophth., XII., 2, 183.

of the refracting media, and especially the lens. In these latter stages, cyclitis and phthisis bulbi * mostly supervene; rarely the opposite condition, viz., glaucomatous inflammation.† Both of these painful complications not infrequently require the removal of the globe—the former on account of threatening sympathetic trouble of the other eye, the latter from the similarity of its symptoms with those of intra-ocular tumors. And, indeed, it has happened in several cases that after the enucleation of such eyeballs, cysticercus was unexpectedly found at the anatomical examination; as, for instance, by *Jacobson*,‡ in a totally atrophied globe, and also by the author, in an eyeball enucleated by *Prof. v. Graefe* for severe glaucomatous inflammation and blindness.

More interesting, however, are those cases where, the total opacity of the refracting media rendering a view of the inner portions of the eye impossible, the diagnosis of cysticercus intra-ocularis was made by way of exclusion, after an accurate anamnesis and examination of the case, and corroborated by the subsequent opening of the eyeball. Such a diagnosis would indeed, as *Prof. v. Graefe* in reporting a case of this kind § remarks, lose of its prac-

* L. c., p. 187.

† *Hirschberg*, Virchow's Archives, XLV.

‡ Arch. f. Ophth., XI., 2, 162.

§ Arch. f. Ophth., XI., 3, 145, Note.—Dr. Steffan, of Frankfurt a. M.,—Clinical Experiençes and Studies, 1869, p. 66,—makes the following remarks about a puzzling case of spontaneous formation of pus in the vitreous body immediately behind the lens:—"A cysticercus could easily produce the same series of symptoms; yet it seems to me that this diagnosis would hardly be justified in this section of the country, where this entozoon is relatively so rare."

tical importance in countries where, unlike ours, cysticercus is relatively infrequent.

A case similar as regards the diagnostics came under my observation a short time ago, and afforded me at the same time the much-desired and rare opportunity of studying anatomically, after the enucleation of the affected eyeball, the changes caused by the presence of the entozoon.

November 25th, 1869, a strong and healthy man came to me on account of violent inflammation and total blindness of his left eye. The blindness had already existed two years; the inflammation had only set in three days ago.

The right eye was normal, vision perfect, yet considerably annoyed in the discharge of its functions by the irritation of its fellow. The left eye was completely amaurotic, and, according to the positive statements of the patient, has had no perception of light whatever for two years. Form and size of the eyeball unchanged; peri-corneal injection marked; iris considerably swollen and discolored, its pupillary margin extensively attached to the greenish opaque and somewhat swollen lens; tension of the eyeball not increased; great sensibility of the ciliary region when touched.

As there was no reason, either in the external influences or in the shape of the eyeball, to suppose a complicated cataract, and especially no symptom whatever pointing to an idiopathic detachment of the retina; moreover the perfect rest and the normal tension of the eyeball, amaurotic for two years, arguing against the existence of an intra-ocular neoplasm, nothing but cysticercus intra-ocularis was remaining as a diagnosis of probabilities. When, notwithstanding the use of atropine and antiphlogistic as well as derivative treatment, the state of irritation, the pains, the tension of the left eye, and especially the annoyance of the right eye, considerably increased, so that it could hardly be opened in the direction of the light, we were no longer in doubt that

surgical interference was demanded. Attempts at extraction of the worm were of course out of the question. I removed the eyeball on the 1st of December, whereby the patient was relieved from all pain, and the other eye from all further irritation.

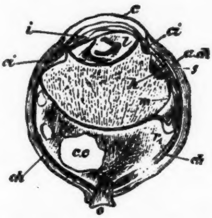
As regards the ætiology I will here remark, that whilst the patient is altogether free from tapeworm, his wife is troubled with it, having at different periods passed large pieces, one nine inches in length.

The extirpated eyeball was opened by a horizontal section after hardening four days in Müller's solution. Only a very small quantity of yellow fluid escaped.

After the completion of the section a folded membranous mass was seen, which proved, upon closer inspection, to be a magnificent specimen of full-grown cysticercus: length of the collapsed mass 14 mm., greatest width 8 mm., head and neck well developed, and on the latter a very strong and well-marked pigmentation of the four suckers, as it is generally seen in a relatively old age of the parasite; all these parts were so delicate and well preserved, that undoubtedly the cysticercus, at the time of the enucleation, was alive, and only the immersion of the specimen in Müller's fluid was the immediate cause of death.

The examination of the section surfaces of the eyeball—that of the upper half of the specimen being represented in the accompanying figure—shows (apart from the iritis, opacity of the lens, or membranous and hemorrhagic products in the atrophied vitreous) *an extensive detachment of the retina, occasioned by a subretinal neoplasm, composed of soft granulation-tissue, in which a large cavity represents the nest of the cysticercus.*

The sclero-corneal capsule remains unaltered. The optic nerve, which macroscopically appears entirely normal, sends, after having passed the scleral opening and lost its marrow at the usual place, a hyaline projection,



Description of the Figure.

c=Cornea. s=Sclerotic. o=Optic nerve. i=Iris. l=Crystalline lens. ci=Ciliary body. ch=Choroid. $a.ch$=Detachment of the retina. h=Hemorrhage in the vitreous. m=Membrane in the vitreous. r=Retina. r_1=Thickening of the retina. g=Granulation tissue under the retina. $c.c.$=Cavity in g. Nest of the cysticercus.

2½ mm. long and half as wide, into the spongy tissue, which fills the greater portion of the interior of the eye, and then ends abruptly. The uvea presents considerable changes in all its parts. The iris is thickened and covered with a delicate deposit extending into the pupillary field; the pupil is irregular, its margin attached by very easily loosened synechiæ to the anterior capsule of the lens, which appears clouded, not only in the superficial cortical layers, but also in the parts more centrally situated around the nucleus proper. The ciliary body, as well as the most anterior portion of the choroid (which is detached from the sclerotic almost to the equator*), is very

*** What seems of importance with regard to sympathetic affection of the other eye may be found in *Mooren*, the Sympathetic Disturbances of Sight, 1869, p.**

much thickened in every portion. This retro-uveal space is thread-like on the inner side of the preparation, whilst outwardly it represents a fissure almost 1 mm. in breadth. The choroid is very much thickened, and, more especially, its outer half. It is apparently stratified, since its color from without inward gradually changes from a saturated brown to a light yellow. The remaining space of the cavity of the eye, lying between the inner surface of the choroid and the posterior surface of the crystalline body, is divided into an anterior and posterior portion by a transverse septum, viz., the protruding retina, which lies almost in the equatorial plane.

The anterior portion, the shrunken vitreous, is traversed by pouch-like fine membranes, which originate for the greater part in a large blood-clot, situated in the outer half of the specimen and lying on the inner surface of the ciliary body, and are attached to the anterior surface of the retina.

The retina itself is only loosely connected with the tissue posterior to it, so that it can be lifted from it with a simple microscope needle; and only behind the coagulum mentioned above, where the retina has a knee-like swelling, does it adhere more firmly to the tissue behind it. Microscopical examination shows that it consists of fibrous tissue with a limited number of small round cells, and also of heaps of pigment (derived probably from blood). The

42, etc., accompanied by anatomical contributions from *Iwanoff;* moreover, in the author's pamphlet in *Zehender's* Clinical Monthly, 1869, p. 297; and the paper by *Rosow* mentioned in the author's article.

large sub-retinal space is filled by a compact but soft mass, which, at the narrow peripheral zone,—*i.e.*, there where it borders on the retina on one side, and on the choroid and optic nerve on the other,—appears grayish and somewhat translucent, but in its greatest thickness seems of a saturated yellow color. It is a vascular granulation-tissue; in the yellow portions the same irregular cells seem pressed more closely, and resemble more the pus-cells.

In the centre of the yellow mass, on the section-surface of the upper half of the specimen, is the irregularly round (6 mm. wide and 5 mm. long) opening to a smooth-walled cavity (devoid, however, of a special parietal membrane), which in a direction upwards and forwards increases considerably in size, on the one side being separated from the upper curvature of the sclera only by a very thin layer, and on the other side extending anteriorly almost to the equator of the lens. Whilst in the lower half of the specimen the presence of a cavity is hardly perceptible, in the upper half there is sufficient space to allow a cysticercus of such a respectable size perfect freedom in his lively and elegant movements.

It is a very interesting fact, when we consider the limited number of the anatomical descriptions of eyeballs with encapsuled cysticerci,* that the case before us should bear such a remarkable resemblance to the one described by the author (in Vol. 45 Virchow's Archives),

* Altogether there are hardly six, which are quoted in my first publication on intra-ocular cysticercus, l. c.

and especially should show with equal clearness the anatomical position of the entozoon. In both cases the cysticercus had developed beneath the retina, had caused total blindness by a complete detachment of the retina, and only after two years' loss of sight had produced, by its very exceptional growth, such violent symptoms of irritation that enucleation of the eye-ball was called for.

GRANULATION TUMORS OF THE IRIS.

By Dr. J. HIRSCHBERG, of Berlin,

and

Dr. STEINHEIM, of Bielefeld.

Translated from the German by Dr. J. H. Pooley, Jr., of Yonkers, N. Y.

Although simple granuloma of the iris has been known from very early times; although it had found, in the year 1834, at the hands of C. G. Linke, an unusually classical description for that time, and although Prof. Von Graefe has lately reported two cases by which he gave a clear illustration of the clinical and anatomical conditions of this rare affection, still a more complete description is wanting in the usual text-books of ophthalmology, as well as in the well-known treatise on tumors by Prof. Virchow. Such a description is all the more desirable, as in the latest periodical literature a few cases have been recorded of which it is doubtful whether they belong to the so-called benign forms of iris tumors or to the malignant sarcomata.

A short discussion on this question has already been presented by one of us (H.) on the occasion of the com-

munication of a case of melanotic sarcoma of the iris (Archiv f. Ophth., XIV., 3, p. 285).

We may therefore be permitted to set forth a condensed statement of the more important of the older observations as an introduction to a new case of granulation tumor of the iris.

In general, really progressive neoplasms of the iris are very rare, but the more interesting, because they are over-arched by the transparent and equally resistant cornea as with a capsule of glass, and thereby completely protected from all external injuries which might change their natural appearances and growth. Moreover they afford, by their being directly observable to the naked eye of the examiner, one of the most beautiful and convenient objects of onkological study on the living body. Thus it is not surprising that already in publications of the last, and the beginning of this century, the iris has been positively alleged to be the origin of the formation of tumors.

But C. G. *Linke* was the first, in his most talented work, "De Fungo Medullari Oculi" (Leipzig, 1834, p. 156), to give an exact description of the form of tumor with which we are dealing. The following descriptions are collected in his work:—

1st. Maître Jean (Traité des Maladies de l'Œil, p. 456, Troyes, 1711). Fungous growth in a soldier which proceeding from the iris, after rupturing the cornea, projected beyond the lids. Under caustic treatment permanent shrivelling and cicatrization.

2d. Saunders (A Treatise on some Practical Points Relating to the Diseases of the Eye, Lond., 1816, p. 142–144). A girl of ten years was blind of one eye, the conjunctival vessels injected, iris attached to the cornea by a vascular mass, pupil wide, refractive media clear. Opacification of the lens, proliferation of the vascular tumor, occupying the whole anterior hemisphere of the globe, and final atrophy followed. Pain had always been moderate.

3d. Ibid., 144–145. In a little boy three years old, the lower part of the iris was apparently occupied by a small deposit of lymph, without change in the pupil.

The new formation became organized, grew, reached the cornea, perforated it with a spongy swelling, which finally spontaneously disappeared.

4th. *Ritterich* (Jährliche Beiträge zur Vervollkommnung, etc., Leipzig, 1827, p. 37). In a cachectic girl of eight years there appeared a whitish tumor on the inner circle of the iris, which occupied most of the pupil to the ciliary margin, and grew towards the posterior surface of the cornea, whilst its yellowish surface became covered with blood-vessels. After an incision it enlarged so much as to cover the whole pupil, and only a small margin of the cornea remained free. At the expiration of a year, spontaneous atrophy of the globe ensued, and the cornea was changed into a dense cicatricial mass.

5th. *Lawrence* (Lancet, X., p. 514, 1826, and Treatise on Diseases of the Eye, p. 593, 1833). Observed in a boy a fleshy vascular swelling of the iris, which per-

forated the cornea and grew out into a fungous mass, ending in spontaneous and permanent collapse of the eyeball.

6th. *Rosas* (Handbuch der Theoretischen und Practischen Augenheilkunde, 11, 617), found in an otherwise perfectly healthy woman, 40 years of age, a tumor occupying one-third of the iris, whilst the rest was perfectly normal.

After the removal of the tumor by excision of the affected portion of the iris it did not return. (Sight remained, reduced to quantitative perception of light.)

7th. *Sichel* (Cannstatt, über den Markschwamm des Auges und das Amaur. Katzenauge, 1831), observed in Jäger's clinic, in a cachectic child one year old, a whitish-red nodular tumor, which projected through a perforation of the inferior part of the cornea and resulted in atrophia bulbi.

The child died of phthisis mesaraica and hydrocephalus acutus. The tumor originated from the ciliary body, and had grown between the iris and the cornea; the rest of the eye showed only changes common to atrophy.

Praël senr. (Von Graefe's und Walther's Journal, XIV., p. 388) observed in one eye of a child a round yellowish tumor of the iris, which pressed it backwards and rendered the pupil oval. After remaining stationary for six months it finally caused pain, perforation, and atrophy. The concluding sentence of Linke deserves to be copied verbatim :—"Hi enim iridis fungi pertinere viden-

tur ad peculiares luxuritiones, quæ non ex cachexia universali prodeuntes initio in certam corporis partem vim exerceant et postea totum corpus corripiant, sed potius ex vitio locali enati solitariam quasi vitam degant et, ubi certum fastigium fuerint assecuti, denique emoriantur. Putaverim equidem, si irritationem et abundantiam vasorum iridis in exordio et progressu morbi respiciam, *huius modi fungos ex præternaturali* retiformium plexus *vasorum* iridis corporisque ciliaris *dilatatione*, amplificatione et prolongatione *una cum nimia telæ cellulosæ vegetatione proficisci.*"

During the following twenty-five years the existence of this disease seems to have been almost entirely forgotten. Whether McKenzie's case (Traité, etc., 11, 265, 14th ed.) belongs to it is questionable.

Prof. *Von Graefe* (Arch. f. Ophth., VII., 2, p. 37, 1860) observed in a girl a year old, besides moderate ciliary injection, cloudiness of the aqueous humor, and a few posterior synechiæ, a dirty yellow, nearly hemispherical tumor, with nodular surface, attached to the tissue of the iris, which slowly increased, but at last perforated the cornea, and projected as a spongy yellowish-white prominence, from which exuded a small quantity of thin pus. Prof. Virchow found in a part of it parvi and multicellular connective tissue, with myéloplaxes and fat; and Prof. Billroth, two months afterwards, mucous granulation tissue. The swelling grew, apparently in a fungoid manner, to a diameter of 6‴, upon which, in consequence of pressure with a bandage and touching with cupri

sulph., a retrogression and permanent atrophy took place. Lues congenita could not be proved; nevertheless the proliferation process appeared to have been dependent upon a dyscrasia. *L. Wecker* (Etudes Ophthal., 11, p. 430, 2d ed.) considers the case as one of condyloma iridis, which opinion is probably incorrect: compare Archiv f. Ophth., XIV., 3, p. 278, No. viii. McKenzie, Traité, etc., 4th ed., p. 261, considers the case a scrofulous tubercle.

10th. *A. Von Graefe* (Archiv f. Ophthal., XII., 2, p. 231, 1866) describes a second case already with the definite designation, "granulation tumor" of the iris, in a child two years of age. The parents stated that, six months before, a yellowish tumor formed in the lower part of the iris, enlarged by degrees, and perforated. The globe was atrophied but irritable; the cornea extensively opaque; part of it, as well as the adjoining sclera, replaced by a new formation, which resembled the granulations of an indolent ulcer, was 5‴ in diameter, and rose scarcely 1‴ above the level of the globe. The mass was soft, yellowish gray, composed of flat granulations, disposed to bleed, between which there was a slight secretion of pus. Enucleatio bulbi. Upon section it was seen that the iris and ciliary body as well as the anterior part of the choroid participated in the tumor; the greater part of the cavity of the globe was filled with fluid. Structure of the new formation similar to that in the first case (also giant cells).

11th. The following case, taken from "Mooren Oph-

thalmiatrische Beobachtungen," 1867, p. 125, although described under another name, viz., telangiectasis of the iris, belongs likewise to this form of tumor. In a Dutch merchant was seen (21st April, 1858), upon the external part of the iris of the right eye, a swelling of at least one year's duration, of the size and appearance of a blackberry, extending into the pupillary region, joining the cornea, and covered with enlarged vessels.

Fundus and vision normal; at each brisk bending forward of the head the whole anterior chamber filled with light red blood,* which reduced sight to quantitative perception of light, but after a minute and a half of rest always disappeared again. Operation not permitted. On the 15th of May, 1862, since the bleeding had disappeared for a year, the tumor was diminished to one-third of its former volume, and had undergone a change to a grayish yellow; considerable disturbance of sight (Jaeger 16), diminution of the field of vision, and slight displacement of the vessels in papilla optica, glaucoma secundarium. Iridectomy again refused; only permitted when, a few months later, sight had wholly disappeared, and the most severe ciliary neuralgia had set in. The tumor removed by the operation was unfortunately lost.

The second eye suffered later from sympathetic irido-choroiditis, but was cured by iridectomy, and the tenderness of the stump of the first diminished. The clinically

* A similar observation of hemorrhage from the apparently perfectly normal iris, upon bending the head, has been communicated by A. Weber, Archiv f. Ophth., VII., 1, p. 65.

very peculiar features of this case evidently resulted from the preponderance of blood-vessels in the tumor.

12th. We include here likewise the case briefly described and illustrated by Dr. *Schelske* (Lehrbuch der Augenheilkunde, 1870, p. 84) of telangiectasis of the iris; if we are not mistaken, it is the same as has been demonstrated by Prof. Von Graefe some time ago in his clinic, with the remark that he considered it a granulation tumor.

There was seen in the lower part of the iris of a young man a reddish yellow mass, with dilated vessels, the growth of which was exceedingly slow.

To these cases, so far described, we have to add the following:—

(No 13.) G. S., a peasant, 21 years old, of slender build, but in robust health, came on the 7th of May to one of us (St.) on account of his right eye, with the statement that some months ago a splinter of wood had flown against the eye,* and caused a protracted redness at its lower part. He had afterwards noticed a white spot in the eye, gradually increasing, and that the power of vision had somewhat decreased. At the examination the eye appeared free from irritation, and its outer coats quite normal; there is no cicatrix to be discovered. The cornea is transparent as far as its margin, only a little congested in its lower periphery, in consequence of the marked venous congestion of the conjunctiva

* The part played by the wound in this case is obscure. Knapp (Intra-ocular Tumors, Eng. ed., p. 300) speaks more at large of the traumatic granulation tumors of the eye.

In a large dog we observed a mushroom-shaped red granulation tumor, which projected through an opening made by sloughing of the cornea, was produced, according to the statement of the owner, by a blow with a piece of wood, and had remained stationary for more than a year.

scleræ. The iris is completely covered in its lower half with a yellowish flesh-colored vascular mass, slightly nodulated on its anterior surface, which begins immediately on the ciliary border, reaches to the lower margin of the pupil, filling the lower portions of the anterior chamber to the posterior wall of the cornea, with which it is closely connected, whilst its upper part gradually decreases in thickness. The upper half of the iris is normal, and of the same slate-gray color as that of the healthy eye. The pupillary margin is fastened to the lens by several synechiæ; the interior of the eye, however, is visible, where no changes are perceptible; the power of vision is scarcely diminished, and the field is not abridged, nor the power of accommodation influenced by the synechiæ. Enucleation was out of question at the time; the patient was informed, however, of the eventual necessity of this emergency. On the 8th July, 1868, at the expiration of a year, he returned, with a materially altered condition of the eye. It was reddened by strong venous injection, lachrymating, hard, and completely blind. At the lower margin of the cornea flesh-colored tumors, separated from each other, were projecting over the level of the cornea, extending, the size of a small hazel-nut, and half as much in height, over the adjacent sclerotic. This portion was covered by slightly uneven injected conjunctiva, resistant to the touch, and completely attached to the sclerotic; between both portions remains a small zone of altered cornea and normal sclerotic. The cornea therefore participates in the process of degeneration, decreasing from below upwards.

Only a small superior part of the iris is visible, manifesting inflammatory changes; upper margin of the pupil adherent and covered with exudation.

On the 9th of July enucleation was performed; the wound healed in a short time; relapse did not occur. At the end of 1869, a year and a half after the enucleation, the patient was quite well, and without the trace of a tumor in the orbit or any other part. The globe, which was hardened in alcohol for a long time, was divided in the vertical meridian, whereby the dissolved vitreous was evacuated; the neoplastic changes were confined entirely to the anterior segment of the globe.

The sclerotic also was thinned in its posterior part, but neither it nor the choroid showed any traces of a tumor.

A moderate, circumscribed thickening of the retina in the neighborhood of the optic nerve entrance, the radius of which is about from two to three diameters of o. d., must be referred to a purely irritative process (neuro-retinitis), as the microscopic examination demonstrates considerable hypertrophy and sclerosis of the fibrous layer to be the cause of the swelling of the retina.

On the contrary, the space of the anterior chamber and the lens—of the latter no trace is discoverable—is replaced by a solid, soft, new formation, which no doubt derives its origin from a hyperplasia of the corpus ciliare and the iris. The mass is homogeneous, of whitish gray color, with a shade of red; posterior surface, looking towards the vitreous space, tolerably smooth.

In the upper part of the anterior chamber, the anterior surface of the new growth shows still a remnant of uveal pigment, in the shape of a small stripe, and lies in close contact with the still transparent cornea, so that by means of the dissecting-needle a slit-shaped opening can be made between them. In the axis of the eye the new formation is united with the staphylomatous cornea, likewise with the thin zone of sclerotic near the lower margin of the cornea. A fine brown line is still recognizable even with the unaided eye, being the remnant of the outer coats of the eye.

The microscopic examination shows as uniform constituents of the new formation a vascular, fibrous, parvi-cellular tissue. The stroma of parallel fibres is richly developed, and even in fine sections, which are not cleaned by a brush, prevails over the cells. The cells are roundish and irregular (shrivelled by alcohol), occasionally short, spindle-shaped, with distinct nuclei, a little larger than that of red blood corpuscles; here and there also many nucleated (myeloplaxes), and consequently larger than the others, whilst proper giant forms are missing.

It is clear that such a structure well deserves the

name of granulation tissue; but it is just as evident that its histological differences from certain forms of sarcoma are only unimportant. If there were any further proofs needed that the microscopic examination of the neoplastic tissue of itself, without regard to the matrix from which it proceeded, is not sufficient to decide upon the pathological importance of the product, the proof would be furnished in these tumors of the iris. Let us recollect that even Prof. Virchow,* in his first histological analysis of a specimen of granuloma iridis, did not express himself definitely on the nature of the formation. Only further special clinical experience justifies us to-day in the conclusion that, if we find any such unpigmented granulation-like structure in a neoplasm of the iris or ciliary body, we need not fear a recurrence or metastasis in remote organs after the complete removal of the diseased parts.

This reason, together with the consideration that the function of the organ is lost in the natural course of the disease, encourages us in surgical interference at an early period of the disease, viz., when vision is still good, and may be preserved by removal of the iris constituting the matrix of the neoplasm. On account of the peripheric origin of the new formation, great difficulties may arise in the performance of the iridectomy, which may best be obviated by using a small knife. In the later stages, after the loss of vision brought about by the growth of the new tissue, there are always symptoms of

* Arch. of Ophth., VII., 2, 38 Mitte.

secondary glaucoma. Enucleatio bulbi would then be preferable to attempts to produce shrivelling of the globe, as the former is quicker and surer, and leads to the same end without danger, which is to free the patient of his disease; and this would be necessary in an earlier period, in case the differential diagnosis from malignant sarcoma cannot be made with certainty.

The relatively youthful age of the patients, the yellow or reddish, decidedly not melanotic color, the uneven surface, and the macroscopic vascularity, the very slow increase of the growth, which projects quite gradually from the iris tissue, might argue for the existence of granuloma, while in the one certain case of sarcoma of the iris the neoplasm presented a smooth, uniformly bluish-black surface.

DO THE EYES PERFORM ANY ROTATION ON THE OPTIC AXES IN LATERAL INCLINATIONS OF THE HEAD?

By Dr. JOSEPH AUB, of Cincinnati:

Assistant-Surgeon to the New York Ophthalmic and Aural Institute.

In a paper published in Vienna during the course of the past summer, by Drs. *Reuss* and *Woinow*, under the title "Ophthalmometric Studies," the latter author makes the remark that Prof. Knapp's method of measuring the curvature of the different meridians of the cornea, by means of a new apparatus for fixing the head, was inaccurate; and for this assertion he gives the following reasons:—

1. The impossibility of bringing the head in exactly the required meridian.

2. The involuntary wheel-turning of the eye consequent on lateral inclinations of the head.

This latter statement being at variance with the results of experiments made by Prof. *Donders* about twenty years ago, Dr. Knapp induced me to make new inquiries into the subject, and suggested the method according to which the following experiments were conducted. The

researches of Donders had only shown, in a general way, that when the head was inclined to either side, the eye did not, as was formerly supposed, rotate upon its axis, so as to keep the vertical meridian always vertical, but that the eye moved in the same direction as the head—that is to say, maintained its relative position to the head.

It is the object of the following investigation to determine whether the eye makes any rotation on the optic axis when the head is inclined to either side, and if so, of what amount it is.

I employed the new apparatus, constructed after the design of Dr. Knapp, for holding the head fixed during observations with the ophthalmometer. The essential part of this apparatus is a dial which is divided into degrees, and turns in an immovable frame. The head is fixed to the dial by lateral pads and a projecting mouthpiece, bearing a cast of the teeth in sealing-wax. *Thus the skeleton of the head is brought in immovable connection with, and must perform the same rotations as, the dial.*

An index on the immovable frame shows how many degrees the head is inclined laterally. If it is possible to determine with the same accuracy the lateral inclination of after-images of the retina, then we are able to find out whether, during lateral inclinations of the head, the eye maintains its relative position to the head or not. The inclination of after-images was determined in the following manner:—

On a wall, twenty feet distant from the observer, I

fixed two pieces of small red ribbon, crossing each other at right angles, one being vertical, the other horizontal. From the crossing-point of the ribbons I described a circle with a radius of 9 inches, and divided it into degrees. The centre of the circle was at the same height as the eyes of the observer. The head being immovably fixed to the dial of the apparatus, and in a vertical position, the observer gazed steadily at the crossing-point of the red ribbons for about half a minute, so as to obtain a distinct after-image. Then the head, together with the dial, was rapidly turned laterally, and the observer, uninterruptedly gazing at the crossing-point of the ribbons, could determine, on the circumference of the circle, how many degrees the after-image was inclined. Some difficulty here manifested itself in exactly determining with which degree the ends of the after-images coincided, since this could only be seen in indirect vision, the eye fixing the centre of the circle. The observer was liable to interrupt the fixation of the centre, in order to see more distinctly the number covered by the end of the after-image; but by so doing his eye frequently made a secondary movement, so that the after-image was shifted to the right or left side of its original position. To obviate this difficulty, radiating cords were drawn from the centre to every 15th degree of the periphery of the circle. If now the periphery was looked at in order to determine the inclination of the after-image, and the eye made a lateral motion, this could be recognized by the fact that the after-image did no longer coincide with the

radiating cord it originally covered, but stood parallel to it, either on the right or the left side. This parallelism indicated just as correctly the original position of the after-image as its coincidence with the cord when the fixation of the centre of the circle was retained. In this manner errors of observation, through the uncertainty of indirect vision, were avoided. The only thing which remained to be done was to compare the degree of lateral inclination of the head, indicated by the apparatus, with the inclination of the after-image, indicated by the graduated circle and its radiating cords.

Repeated experiments of my own and of Drs. H. Knapp, H. C. Scott, Charles Bacon, and some other gentlemen, had the unvarying result that the inclination of the after-image was either the same as that of the head, or deviated from it only 1 to 4 degrees on the one or the other side. Since this slight deviation is to be considered an error of observation, it is proved, contrary to the assertion of Drs. *Reuss* and *Woinow*, that in lateral inclinations of the head and straightforward direction of the visual line, the eye does not make any rotation around the optic axis whatever.

The above experiments confirm, therefore, the statements of Donders and other observers, according to which the eye, in general, follows the lateral inclinations of the head; but these observers failed to demonstrate that this is done exactly to the same degree. This uncertainty is removed by our experiments, which proved that the lateral inclination of the eyes is not only of the

same direction, but also of the same degree as that of the head.

I am unaware upon which investigation the above-quoted assertions of Drs. *Reuss* and *Woinow* are based.

With regard to the accuracy of determining the lateral inclination of the head by means of Dr. Knapp's apparatus, Dr. Knapp requests me to state that the apparatus which he had had constructed, shortly before his departure from Heidelberg, had no mouthpiece, and did not hold the head tightly enough to follow to the degree the rotations of the dial. It was, however, as is conceded also by Drs. *Reuss* and *Woinow*, accurate enough for ascertaining the astigmatism of the cornea after cataract operations, with which Dr. Knapp had occupied himself during the summer of 1868, and obtained results similar to those published subsequently by Reuss and Woinow. The addition of the mouthpiece, not allowing any movements of the head other than those of the dial, combined with the results of our investigations, according to which the eye makes no involuntary wheel-rotation in lateral inclination of the head, renders the apparatus and the method of Dr. Knapp for measuring the meridians of the cornea entirely unexceptionable with regard to accuracy.

THE MECHANISM OF THE ORGAN OF HEARING.

By H. KAISER, M.D., of Dieburg.

Translated from the German by Albert H. Buck, M.D.

To understand the mechanical conditions which play an important part in the act of hearing, especially in man, it is not necessary to commence new studies in higher mechanics or to enter into complicated calculations; the well-known physical doctrines suffice here fully. We shall have to refer to higher mathematics only when we come to consider, in the first place, how the *membrana tympani* can be excited to sympathetic vibration by a sound-producing body, and, in the next place, how the handle of the hammer can so easily follow the vibrations of the membrane without acting as a hindrance.

Whilst studying the present condition of science with reference to the function of hearing, it seemed to us that, on the one hand, certain points were not brought out with sufficient clearness, whilst others were entirely overlooked. In reference especially to the mechanical effect produced upon the terminal nerve branches, whose function is to receive the impressions of sound, we found no explanation that gave us entire satisfaction.

We felt convinced that it was the function of the organ of hearing—which, though relatively simple, is yet complicated when considered by itself—to transmit to the terminal branches of our auditory nerve, in as concentrated a form as possible, the impressions produced upon the superficies of the membrana tympani by vibrations of sound occurring in the medium with which the membrane stands in contact; just like what occurs in the organ of sight, where the corneo-lenticular system transmits in a concentrated form to the retina all the rays of light which proceed from a luminous point, and reach the pupil. And, moreover, the better we were able to understand the function of the individual parts of the auditory apparatus, and the arrangement of its mechanism as a whole, the more we became confirmed in our view.

As in our paper on the mechanism of the accommodation of the eye,* we shall first state the physical and mechanical principles involved in the action of the auditory apparatus, and then consider successively the parts played by the individual elements of this apparatus, reserving for the last the consideration of the function of hearing in its totality, as it will naturally follow from the premises.

I. PHYSICAL PRINCIPLES.

1. Here too, as in the mechanism of the accommodation of the eye, the incompressibility of the aqueous

* Reichert's and Du Bois-Reymond's Archives, 1868, 3.

fluids must first be taken into consideration. Inasmuch as the volume of water is diminished only 0.00005 under the pressure of one atmosphere, we can consider the fluid of the labyrinth as entirely incompressible under the slight pressure to which it is submitted. As a result of this, the pressure made by an aqueous fluid, which is surrounded by immovable walls, upon an object contained within it, is as great as that exerted by a perfectly solid body, whose surfaces of contact are at the same time entirely free from every roughness, for the surface of fluids is perfectly smooth.

2. Waves of sound produced in an open space, or in cylindrical tubes of infinite length, are *progressive.* If l = the length of the waves, and a = the rate of progression of sound in the air, and x = the distance from the centre of concussion, then the vibration at the time t will reach from $x = a\,t - \frac{l}{2}$ to $x = a\,t + \frac{l}{2}$. If, therefore, x' = the distance of a membrane (which is capable of receiving the motion, and vibrating with it) from the starting-point of the concussion, then the wave reaches the membrane at the time $t_1 = \frac{x' - \frac{1}{2}l}{a}$ and leaves it at the time $t_2 = \frac{x' + \frac{1}{2}l}{a}$. The wave therefore traverses, as it were, in all its phases the membrane in the time $t_2 - t_1 = \frac{l}{a}$ —inasmuch as no disturbance is produced by the reflection of the waves, as experience teaches,—and imparts its vibration to it as far as a single shock is able to do. If,

now, the sound-producing cause continue till a certain number of equal waves have traversed the membrane, it will excite in it comparatively strong sympathetic vibrations.

3. In the mechanism of the ear we have not to deal with so-called "standing" waves, as they are formed in tubes of finite length, because the individual spaces and canals of the organ of hearing are too small to produce an independent formation of waves.*

4. Vibrations of sound are easily imparted to a thin stretched membrane, the same as to a thin wooden tablet.

It is well known that the sounding-board of stringed instruments, which consists of a thin wooden tablet, vibrates sympathetically with the strings extended over it, and that the vibrations which have thus been produced in the air impress our organ of hearing with all the force of the instrument, while the vibrations caused by the strings alone are scarcely perceptible.

Stretched membranes are so much the more fitted to vibrate sympathetically with all sorts of tones, as they are able of themselves, on account of their physical characteristics, to produce an infinite number of tones.†

* A consonance of the air contained in the cavity of the tympanum can take place only when, the membrana tympani being destroyed, such tones are sounded the quarter length of whose waves does not differ much from the length of the external auditory canal, plus that of the tympanum. Compare, however, a remark under the heading "*Membrana Tympani*"!

† See Lamé, Leçons s. l. théorie math. de l'élasticité des corps solides, dixième leçon.

A rod moreover, when intimately united to a membrane, and extending from its centre to beyond the periphery, is fitted to follow the membrane in all its vibrations; and indeed the more so from the fact that such a rod will, if caused to vibrate by itself, in accordance with physical laws, carry out just the same kind of undulations as a radial fibre of the membrane.*

* The differential equation for the transverse vibrations of a homogeneous elastic membrane is:—

$$\frac{d^2w}{dt^2} = c\left(\frac{d^2w}{dx^2} + \frac{d^2w}{dy^2}\right),$$

from which, by integration, we find the formula for a membrane stretched over a circular ring of the radius *r* (it being assumed that the origin of the co-ordinate is in the centre):

$$w = \Sigma A_1 \left(H \cos \gamma t + H' \sin \gamma t\right)\left(2^2 - x^2 - y^2\right)^i, \quad (\odot)$$

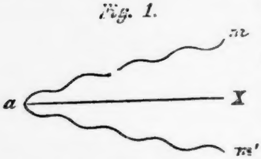
where H and H′ are constant magnitudes, and A_1 denotes a factor, which decreases in proportion to the increase of the index *i*, and is independent of the variables *x*, *y*, and *t*.

The integral for the vibrating motion of a thin elastic rod, according to Poisson (Traité de mécanique, II., page 377), is found in the formula:—

$$y = \Sigma X \left(E \cos \gamma' t + E' \sin \gamma' t\right). \quad (☽)$$

Although γ' in (☽) is not identical with γ in ($\odot$), nor X with $A_1 (r^2 - x^2 - y^2)^i$, still from the similarity of both formulæ we may be allowed to draw the conclusion, that an elastic rod (which is interwoven with an elastic membrane and does not materially differ from it in its nature, especially as regards elasticity) can participate in the vibrations of the radial fibres of that membrane without at the same time disturbing its vibrations as a whole. The discussion of the equation X = o (loco citato) affords only one real positive root, that is x = o.

Fig. 1.



Besides its point of attachment, therefore, the rod has none other which can remain quiet during the motion. The value of X constantly increases with x, and the form of the motion is therefore similar to that represented in Fig. 1, where the two extreme positions of the rod are represented by *a m* and *a m′*, and a point in the circular border of the membrane by *a*.

5. Small volumes of air, or short columns of fluid, when put in motion by vibrating membranes, must be considered as media that are only to be affected in their totality, and uniformly, provided their dimensions are so small in comparison with the length of the waves of sound that their density and rate of speed (when affected by the wave) remain in all the layers very nearly the same.

6. The intensity of sound diminishes according to the square of the distance. The rate of progression of sound in air is 1022 Parisian feet per second. If l represent the length of the wave of sound, a = the rate of progression, and n = the number of vibrations, then, since $l = \frac{a}{n}$ we shall have for *C* of the contra-octave $l = \frac{1022}{33} = 30.97$ feet, and for $\overset{\equiv}{b}$, $l = \frac{1022}{3690} = 0.28$ foot = 3.36 inches.

The length of the wave ranges, therefore, from $3\frac{1}{3}$ inches to 31 feet, or even to 64 feet, if we take the deepest tone which a closed pipe 16 feet long can give.

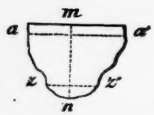
The rate of progression in air being such as we have mentioned it, in water about four times as much, and in solid bodies still greater, the motion of individual vibrating molecules of a stretched membrane is, on the contrary, exceedingly slow.

If the distance traversed by an oscillating particle, during its to-and-fro motion (corresponding to the to-and-fro motion of a wave) be fixed at one-tenth of a millimetre, then, inasmuch as the length of the wave produ-

cing the tone c = 1 metre, the rate of its progression in air will be 10,000 times, and in water nearly 40,000 times greater than the rate of oscillation of a particle of the membrane.*

If air be contained in a space surrounded partly by solid walls, and partly by a vibrating membrane *m* (Fig. 2), and if the space be of so small dimensions that an equally large portion of the wave which causes the membrane to vibrate may be considered as homogeneous with regard to velocity and density, then the vibrating membrane acts upon the air which is contained within the cavity in the following manner:—

Fig. 2.



If the membrane has just commenced its motion, and the layer *a a'*, which is parallel to it, has passed over an infinitely small portion of its course, in the direction *m n*, then the shock has already been propagated also to the last layer, *z z'*. It can therefore be assumed that all the layers of air which are parallel to the membrane approach the opposite wall, *n*, and recede from it on the return of the wave, at the same time and with the same force. It follows from this, that under the conditions just mentioned, a vibration of the membrane has the effect only of a gradually increasing condensation and rarefaction upon the enclosed air.

* The vibrations of all the parts of the organ of hearing are, it is true, isochronous with those of the *membrana tympani*, but yet—leaving out of consideration the air contained within the cavity of the tympanum—they do not exactly equal them in their excursions.

But if a small space surrounded by solid walls, r s (Fig. 3), and shut in by two membranes, m $m_{,,}$ were filled with water, then a condensation of the water, owing to its incompressibility, could not take place; consequently the enclosed water would have to remain perfectly quiet, provided, of course, the pressure upon both membranes were equal. Such would be the case if both of the membranes m $m_{,,}$ which shut in the water, were connected with a space m M $m_{,,}$ containing air like the one previously supposed, and the oscillating motion originated in the membrane M.

Fig. 3.

But if the pressure upon m and $m_{,}$ were not the same, that is, if the pressure upon m were greater than upon $m_{,,}$ then the entire fluid would move in the direction from m to $m_{,,}$ and continue its course in that direction until the gradually increasing tension of the membranes would oppose an equal force to the pressure exerted upon m. The motion upon the water would gradually slacken, it would come to rest, and then swing back with gradually increasing speed in the opposite direction. The entire mass of the fluid would therefore act like a pendulum, vibrating with a very short excursion.

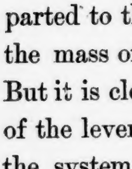
Fig. 4.

If the canal m r s $m_{,}$ (Fig. 4), had a side branch, x, the water contained within it would experience a similar oscillation; in y, moreover, where the courses of the particles

of water cross each other, a sort of eddy would be created.

7. The effect of a force impelling the mass M, if reckoned from the point of time when the velocity of the mass was 0, up to the time when it equals v, may be expressed by $\frac{1}{2} My^2$. The mass M, to which the velocity v was communicated, can now likewise produce the same mechanical effect as the force which has acted upon it. Hence the effective power of a body in motion, whose mathematical expression is $\frac{1}{2} Mv^2$, is called its "vis viva" (potential energy). The greater therefore the value of M, where the value of v remains the same, the greater will be the effective power. Let a b c (Fig. 5) represent three thin stretched membranes, and a united to b by means of a comparatively heavy lever, d. Let the space a b c be filled with air, and the tube b e c entirely filled with water. If now the mass of the lever d be equivalent to M, and the velocity v be imparted to the membrane a, then the energy exerted upon the mass of water in b e c will be expressed by $\frac{1}{2} Mv^2$. But it is clear that this force increases with the mass M of the lever, and that in consequence of the law of inertia the system (comprising the membranes, the lever, and the mass of water which it puts in vibration) will continue its motion even after the cause that put the membrane a in vibration has ceased; and the greater the volume of the entire vibrating system, the longer the motion will continue. If the membrane a possesses a

Fig. 5.



regulator which can counteract its vibrations,* then the duration of the oscillation of the system, which, owing to the vis inertiæ of the mass, continues after the external exciting cause has ceased, will depend on the relation of the power of the regulator to the weight of the masses of the system.

It is scarcely necessary to add that these principles may be applied to the organ of hearing as a whole, and also to its component parts. By means of these principles we hope to succeed in giving a clear representation of how this apparatus fulfils the purpose for which it was intended, in as simple though perfect a manner as we might expect from the economy of nature, viz.: to make the most effective impression possible upon the terminal branches of the auditory nerve by means of the waves of sound which enter the ear.

II.—The different parts of the auditory apparatus.

1. The Auricle.—All rays of sound which do not enter directly into the external auditory canal can only reach it by being reflected from the inner surface of the concha. Since the plane, tangent to the anthelix and tragus, forms with the median plane an angle of about 35°, and since both ears are turned symmetrically in opposite directions, there remains a space behind the body which is enclosed by

* In our opinion the *musculus tensor tympani* performs the part of such a regulator of the *membrana tympani*.

two vertical planes forming together an angle of 70°, and within which a direct transmission of sound to the external auditory canal is impossible. Those waves of sound, therefore, which strike the back part of the head within this space, are shut off from the possibility of reaching directly the external auditory canal, whilst all the others that fall within the remaining space of 290°, can reach the ear either directly or by aid of the conchæ. From all sonorous points, however, situated behind the listener, spherical waves proceed, which are disturbed, it is true, by the body of the person whom they strike, but still unite again later into a uniform whole, from which regular waves then travel backwards into both ears. Inasmuch as the intensity of waves of sound decreases in proportion to the square of the distance, and energy is lost through the aforementioned disturbance, these waves will therefore be considerably weaker than the direct waves.

The waves reflected by the conchæ do not differ very materially in point of intensity from those which enter the external auditory canal directly, neither do they differ essentially from these in the magnitude of their phasis—that is, with reference to the length of the waves which we have here to consider. (This is, however, not true of waves reflected from objects more or less remote from the ear, as is most strikingly proven by the phenomenon of the echo.) That the intensity of sound should be so slightly diminished by reflection from the inner surface of the concha, can only be explained by supposing that the waves are reflected without appreciable loss of energy

—a circumstance due to the firmness and elasticity of the cartilage of the auricle. The construction and nature of the latter render it, in our opinion, peculiarly adapted to afford the requisite firmness and elasticity. There may be some truth in the assertion that the form of the concha enables it to present a perpendicular surface to the rays of sound coming from any direction whatsoever, and thus always to convey a portion of them to the external auditory canal; but no very great value can be attached, in our opinion, to this advantage alone.

In animals the concha, with its flap-like appendage, often serves to protect the ear, as the eyelids protect the eye; at the same time it presents a movable funnel for the better reception of the rays of sound and for the determination of their direction.

In man, the direction from which a sound comes is also chiefly determined by the concha, and especially by means of the reflections from its inner surface; the faculty of determining the source of these reflections being gradually acquired from earliest childhood.

On the use of the concha in agitated air, we shall make some remarks in the following section.

2. The External Auditory Canal.—In a mechanical point of view the external auditory canal offers little of interest. Its anterior third, where reflection takes place more than in the deeper parts, is chiefly cartilaginous, and it would seem as if here too the elasticity of the cartilage played an important part. When we compare the length of sound-waves with the narrowness of the canal, we

cannot admit the possibility of any change in the phases of the waves which are reflected from its walls.

The external meatus serves, in the first place, to prevent the transmission of extremes of temperature to the middle and internal ear; this is accomplished by means of the tempered air contained within the external auditory canal, which acts as a poor conductor. (In animals an abundance of hairs in the external auditory canal serves the same purpose.) By its length, moreover, it protects the membrana tympani from injurious mechanical influences.* In the next place, the disturbing influences caused by frequently occurring violent atmospheric commotions are very much mitigated by the length of the external auditory canal. If, for instance, the membrana tympani were directly exposed to the external air, while the latter was moved by the wind only at the rate of 12 feet per second, then, upon the intonation of any tones below $\bar{a}$, none of the particles of air in the immediate neighborhood of the membrane, owing to the slowness of their oscillations, could complete their vibrations against the membrana tympani; new ones would constantly come up, which, although being in the same phasis as the preceding, would cause a considerable loss of energy. Moreover those rays of sound which proceed within a short distance from the original surface of vibration, as, for instance, from the section of a person's mouth, speaking

*** Politzer (Beleuchtungsbilder des Trommelfells, page 120) speaks of a prairie dog (in which animals the *membrana tympani* lies very near the surface, owing to the shortness of the external auditory canal), in whom he found a fracture of the *manubrium mallei*.**

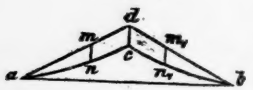
toward the ear of the listener, could no longer reach the membrana tympani; only the weaker side waves would reach it.

At a somewhat greater distance, however, this disadvantage would still present itself, provided the external auditory canal were existing, but the concha wanting. The latter, by its extent of surface, increases very materially the limit within which the most effective rays of sound can reach our ears.

3. The Membrana Tympani.—Sympathetic vibrations are excited in the membrana tympani by a number of uniform undulations, corresponding to the length of the waves of a sound or tone, in the same manner as they are excited in a tuning-fork (armed with a suitable resonator) by another tuning-fork, which is tuned to the pitch of the former, and may be held at a considerable distance from it. The construction and form of the membrana tympani is highly favorable for the important function of conveying to the internal ear, not the waves of condensation and rarefaction of the medium which serves as their substratum, but the periodical and rhythmical molecular motion caused by them. This membrane consists on the outer side of radial, on the inner, of circular tendinous fibres. The former of these are held in a state of great tension by the traction of the handle of the hammer, whilst the latter are only moderately stretched. By the simultaneous action of both, a section of the membrane assumes the form *a*, *c*, *b* (Fig. 6). If now, by a pressure from without, the radial fibres are put on the

stretch whilst the circular ones at the same time yield, then a section of the membrane will approach the form

Fig. 6.



of the rectilinear triangle *a d b*. In a motion of this kind, the particles of air which strike the surface *a c b* lose the smallest possible amount of energy, because all the particles of the membrana tympani move in directions which are nearly parallel to *c d*, and therefore, the moment their inertia has been overcome, they will return by almost the same route as that taken by the particles of air which cause the motion, since the directions *n c*, and *n′ c*, are nearly parallel to *m d*, and *m′ d*.* If the membrana tympani were even, then not only at the border, but also more toward the middle, the vibrating particles of air which act upon the membrane would lose a considerable amount of their energy. Under these circumstances the strength of the effect produced upon the membrana tympani is materially increased, first, by the inclined position of that membrane, as a whole, to the axis of the external auditory canal; and next—especially since the phases of the waves of air which strike it can be considered as perfectly equal—by the considerable increase of its surface.

The tension of the membrana tympani may be increased

* During that short interval of time, within which the membrane has not yet attained the speed of the particles of air which excite its motion, the latter, rebounding from the portion *n c*, of the membrane, are thrown mostly upon the portion *n, c*, where they produce their mechanical effect, as those reflected from *n, c*, on the portion *n c*.

by the contraction of the musculus tensor tympani. Since by increasing the tension of a membrane its pitch is elevated, it may be assumed that this muscle is capable of rendering the membrane more sensitive for the reception and transmission of certain tones. In this particular the action of this muscle resembles somewhat that of the ciliary muscle. But even without the assistance of this muscle the membrana tympani must be so disposed that it can vibrate with the many different tones which reach it, otherwise a sudden succession of high and deep tones could not be accurately appreciated, for the tensor muscle would not have time to accommodate itself.* The principal function of the *musculus tensor tympani* seems to be that of a damper [mute] of the membrana tympani, being fitted not only to moderate, by means of strong contraction, too great excursions of the latter, but also to prevent a continuation of the sensation of sound after the production of the waves has ceased.

4. The Cavity of the Tympanum.—The opening in the tympanum which leads to the Eustachian tube has this mechanical importance, that by means of it the tension and temperature of the air in the cavities of the pharynx and tympanum may be kept in a state of equilibrium. In the consideration of the acoustic functions of the cavity of the tympanum, and especially in regard to the question whether they are modified by the occurrence of condensations and rarefactions in the air of the Eustachian tube, it may be stated that, according to the in-

* See E. Mach, Sitzungsbericht der Wiener Akademie, Bd. 48.

vestigations of Prof. Moos, which confirm the views of the older authorities, this tube is closed when in a state of rest.*

As a general rule, the relation of the parts in the cavity of the tympanum to one another is such as is represented in Fig. 5, where *a* designates the *membrana tympani*, *b c* the membranes of the *fenestræ ovalis* and *rotunda*, and *d* the chain of ossicles.

Although the air enclosed within the cavity of the tympanum is alternately condensed and rarefied, it nevertheless differs from a standing wave in this, that all its layers (in almost all cases) are of equal density. Only the waves of very high tones, whose lengths are nearly four times the length of the cavity of the tympanum, can, in the opinion of Helmholtz, create a resonance within that cavity.

If the bones of the ear were wanting, or their continuity broken, there would be an equal pressure upon both fenestræ of the labyrinth, and the fluid contained within it would have to remain at perfect rest. In such a case the presence of an entire membrana tympani (or of an artificial one), besides affording protection against the extremes of temperature, and favoring the conduction of sound through the cranial bones, would render possible the transmission of the vibrations of that membrane in a direction perpendicular to the membranes of both fenestræ, and in the form of periodical pressures upon those membranes. Were no membrana tympani present, the

* See the last paper of this volume.

vibrations of sound in the air, being nearly parallel in direction with those membranes, could affect them only slightly.

The pressure which is exerted upon the membranes of these fenestræ, in consequence of the vibrations of the membrana tympani, can be approximately expressed by

$$\rho \frac{z}{z_{,} - z},$$

where ρ = the pressure of one atmosphere, $z_{,}$ the length of the cavity of the tympanum, and z the distance of a particle of the vibrating membrana tympani from its position of rest. Inasmuch as ρ varies with the height of the barometer, the intensity of the effect of sound upon the aforementioned membranes (and consequently upon the terminal branches of the acoustic nerve) will also be much stronger with a high stand of the barometer than with a low one.

5. *The Ossicles of Hearing.*—Where the vibrations of the air surrounding the membrana tympani on both sides are not too powerful, the ossicles are considered by modern physiologists—and I think rightly—to play the part of a single body, which is intimately united with the aforementioned membrane. To prevent their articular surfaces from gliding upon one another, the hammer and anvil are fitted into one another, according to Helmholtz, in such a way that, in all motions of the membrana tympani inwards, their union will be firm, whilst in the motions of the membrane outwards they may, to a certain extent, be separated from each other. Helmholtz com-

pares this arrangement to the ratchet-wheel of a modern watch-key, which admits of being wound up in only one direction. By means of this arrangement the stirrup is protected from a too violent traction, and the possibility of being torn from the membrane of the fenestra ovalis. In consequence of the intimate union existing between the ossicles, they may be considered as a single two-armed lever, which has its fulcrum at the point where the end of the short process of the anvil rests against the wall of the cavity of the tympanum, its short arm being connected with the membrane of the fenestra ovalis, and its long arm with the membrana tympani. In this connection it must be borne in mind that in man the handle of the hammer is about $1\frac{1}{2}$ times as long as the long process of the anvil, and that therefore the pressure exerted upon the stirrup is $1\frac{1}{2}$ times as great as the force brought to bear upon the handle of the hammer, whilst the excursion of the membrane of the fenestra ovalis in the normal direction is only $\frac{2}{3}$ of that of the membrana tympani. Owing to the fact that this latter membrane can only be stretched so far inwards as to form a very obtuse-angled cone with straight edges (a section of it would have the form *a d b*, Fig. 6), the membrane of the fenestra ovalis is protected from the effects of those strong concussions, which often reach the membrana tympani and ossicles by way of the external auditory canal.

Of the force originally communicated to the membrana tympani, there is lost in the transmission of the motion to the membrane of the fenestra ovalis: (1) that

which is absorbed in the molecular vibration of the ossicles; (2) so much as is necessary to condense the air contained within the cavity of the tympanum; and (3) that which, owing to the resistance of the membranes of the oval and round fenestræ, is expended on the neighboring mass of bone.

As regards the muscles which are attached to the ossicles, nothing more need be said concerning the musculus tensor tympani beyond what has already been mentioned in the section on the membrana tympani. Concerning the musculus stapedius it must be remarked, that its power of changing the position of the stirrup would seem to be for the purpose of voluntarily rendering the sensation of hearing more or less acute, as may be wanted.

6. *The Labyrinth.*—The length of the semicircular canals and *scalæ* of the cochlea is likewise so inconsiderable that the fluid of the labyrinth may be said to vibrate to and fro as a whole. The entire mass of fluid, however, performs its minute pendulum-like excursions in several narrow canals, which all (with one exception) communicate directly with a kind of cistern (the vestibule). While all the rest communicate with the cavity of the tympanum only through this cistern, whose floor (facing the cavity of the tympanum) is closed by the membrane of the fenestra ovalis, this one canal—the scala tympani—is brought in contact with the cavity of the tympanum by means of the membrane of the fenestra rotunda, and communicates on the other hand only through a narrow opening with the tube that is parallel to it (scala vesti-

buli). In a mechanical point of view this is very important, inasmuch as otherwise a motion of the fluid of the labyrinth could not take place.

The transverse and longitudinal vibrations, which are transmitted through the ossicles from the membrana tympani to the membrane of the fenestra ovalis, travel through the entire fluid of the labyrinth about four times faster than in the air, and therefore every phasis of vibration of the membrane of the fenestra ovalis is transmitted, one may say, almost instantaneously to the membrane of the fenestra rotunda. Inasmuch as the fluid of the labyrinth (taking no account here of the membranes contained within it) is incompressible, being surrounded by solid walls, the membrane of the fenestra rotunda will be forced outwards, toward the cavity of the tympanum, exactly in proportion as the membrane of the fenestra ovalis has been pressed inwards, and to the same extent also will the fluid of the labyrinth be displaced from its position of equilibrium. The membrane of the fenestra rotunda being (in proportion to its small superficies) less yielding to pressure, the motion of the fluid has to overcome a resistance which must cause a corresponding pressure upon the membranous labyrinth, and especially upon the lamina membranacea, which forms the wall of separation between the two divisions of the fluid contained within the cochlea—for both of these divisions are under the same atmospheric pressure.

The motion of the fluid commences in the vestibule; that part of it contained within the semicircular canals

must at first remain quiet, because the pressure upon both ends of each of these tubes is the same; only the fluid contained within the cochlea is pushed onward. On the return of the motion, however, the fluid in the semicircular canals (especially in the ends which are provided with ampullæ, and hence offer less friction) will be caused to move at first in the direction of the membrane of the *fenestra ovalis*, for the pressure upon this part of the fluid, which is in the immediate neighborhood of the vestibule or common cistern, is the same as upon the fluid of the cochlea. Owing to the circumstance that the fluid, on its return from the *scala vestibuli*, crosses the stream coming from the semicircular canals, a microscopical eddy is produced, which very probably is able to put in motion the fine sand contained within the little sacks of the vestibule. The participation of the contents of the semicircular canals in this return motion is favored by the circumstance that the *scala tympani* communicates with the *scala vestibuli* only through a narrow opening (*helicotrema*), which indeed cannot offer any obstacle to the propagation of hydrostatic pressure, but can nevertheless retard the motion somewhat by friction.

While, then, this pendulum-like motion of the fluid (within exceedingly small limits of excursion) is repeated in a second, as often as the pitch of the tone requires, the fluid of the labyrinth — being incompressible, but free from every roughness—exerts an increasing and decreasing pressure upon the membranous struc-

tures of the labyrinth, upon which the terminal branches of the acoustic nerve are spread out. That Nature has assigned this office to water, on account of its smoothness and incompressibility, seems to us also to be corroborated by the existence of the peri- and endolymph, surrounding and filling the semicircular membranous canals.

Finally, the shape of the cochlea deserves special mention. It affords in the membrane of Corti a comparatively large surface for the expansion of the terminal branches of the acoustic nerve within a small space; and this surface is subjected to the periodical pressures just mentioned.

III.—The function of the organ of hearing considered as a whole.

To avoid repetition as much as possible, we shall of course leave out here much of what was mentioned in the description of the individual parts of the mechanism of the ear; but the reader will pardon us if we cannot avoid repetitions entirely. They will not be without use, we trust, at a time when so many, as we think, obscure descriptions of the true functions of the apparatus of hearing are in circulation.

The *membrana tympani* is put into a state of periodic vibration by a greater or smaller number (according to the duration of the exciting cause) of waves of condensation and rarefaction, occurring in the neighboring medium (usually atmospheric air), and which for one and the

same tone are perfectly equal. This periodic motion is transferred with the same rhythm, and with but little loss, through the ossicles to the membrane of the *fenestra ovalis.* From here it is transmitted almost instantaneously (in about 0.0001 of a second) to the membrane of the *fenestra rotunda*, causing it to bulge outwards toward the cavity of the tympanum to the same extent as the membrane of the fenestra ovalis is forced inwards toward the labyrinth. The fluid contained in this latter cavity participates in this motion as one mass. On reaching its limit in this direction the motion is then exactly reversed.

This very slight motion, which, as in the pendulum, grows gradually swifter, then again becomes slower, and after a moment of rest goes through the same stages in the opposite direction, starts from the membrane of the fenestra ovalis, goes first in the direction of the *scala vestibuli* of the cochlea, then through the *scala tympani* toward the *fenestra rotunda;* when the membrane of this fenestra has reached its greatest degree of tension the motion is reversed, and passes first through the *scala tympani*, then through the *scala vestibuli*, finally through the semicircular canals, and partly also, by the way of the vestibule, direct to the membrane of the *fenestra ovalis.* Through the crossing of these two streams a small eddy is produced, which causes motion in the microscopical particles of sand contained within the vestibule.

The pressure proceeding from the *membrana tympani*,

and the necessarily equal counter-pressure due to the elasticity of the membrane of the *fenestra rotunda*, are transmitted to the membranous structures contained within the labyrinth, and consequently to the terminal ends of the acoustic nerve spread out on those membranes, the construction of which is peculiarly complicated, and bears some analogy to that of the optic nerve. This pressure grows greater or less in exact harmony (as regards time and intensity) with the waves in the external air, and is accompanied by a simultaneous slight to-and-fro motion of the membranes. The relative slowness not only of the molecular motion caused by the pressure, but also of the last-named undulatory movement, gives to the nerves the requisite time for apprehending and conveying them to the brain.

The nature of the final mechanical effect of the auditory apparatus must be assumed to consist in the oft-mentioned periodical pressures upon the membranes of the labyrinth, since the hearing may yet remain tolerably good even after the continuity of the ossicles has been broken, and consequently the motion of the fluid in the labyrinth stopped.

In the latter case the membranes of both fenestræ (in consequence of the periodically increasing and diminishing pressure made upon them by the air in the tympanum, and also in consequence of consonant vibration, which cannot, however, take place in the form of an actual motion) will produce a periodical pressure on the fluid of the labyrinth, and on the terminal branches of

the acoustic nerve spread out within it. The part played in the auditory apparatus by the *membrana tympani*, in connection with the membrane of the *fenestra ovalis*, is analogous to that played by the cornea in connection with the lens, in the organ of sight. In so far as their superficial expansion will permit, both receive external vibrations—whether of the air or of the ether—in order to transmit them with the strongest possible effect to the terminal branches of the nerve, whose special function is to convey to the brain the corresponding impressions. As regards the mode of accomplishing this effect, however, Nature has followed widely diverging ways in the construction of both apparatuses. In the organ of sight of the higher animals, the chief feature of the action consists in reconcentrating at one point of the distribution of the optic nerve (in order to produce at this point the strongest possible irritation) all the rays which emanate from a luminous point and strike the corneo-lenticular system ; but the final effect of the auditory apparatus consists in this, that the rays of sound which reach the internal ear are made to produce the strongest and most uniform effect possible upon the entire terminal ramification of the auditory nerve, which is spread out over a comparatively large surface.*

When we hear music, the above-mentioned periodical pressures produce at the same time, in both ears, a minia-

* This effect is produced here in the same manner as in the hydraulic press, where the amount of pressure exerted upon a comparatively slender column of fluid can be brought to bear with equal intensity upon a surface of almost any size.

ture copy of the music on the membranous structures of the labyrinth, just as when we look at a landscape the rays of light, refracted by the optical apparatus of our eyes, produce a miniature copy of the landscape on the retinæ. If the first could be made as audible as the latter can be made visible,* still the essence of the faculty of hearing, respectively, of sight, would not have to be sought for in these miniature copies; but we must assume that this essence is only to be found in the powerful effect produced by the vibrations of the air or ether (through the assistance of the apparatus specially arranged for this purpose) upon the specifically organized terminal distribution of both nerves of sense.

Helmholtz, that most eminent scientist, to whom acoustics and the physiology of hearing owe so much, is of opinion that the cerebral faculty of perceiving distinctly the several tones is founded on sympathetic vibrations of the individual fibres of Corti, each one of which is tuned to a corresponding tone. Regarding this view, we have to say that we cannot accept the term sympathetic vibration in this connection as meaning the sympathetic vibrations of a string, tuning-fork, etc., which are caused by the simultaneous vibrations of another sounding body of the same nature and pitch. We can only understand it to mean, that for every tone there is a corresponding fibre of Corti's organ, which is supposed to be specially affected by its intonation, and to commu-

* By the well-known experiment of removing a portion of the sclerotic near the posterior pole of the eye.

nicate its own disturbance to a brain fibre with which it is connected.

Our explanation of the final mechanical effect of the auditory apparatus, interpreted in this light, does not in any way conflict with the above-mentioned hypothesis.

As regards the perception of different tones at the same time, we would make the following remarks:—According to Principle 4, the membrana tympani, in its character of a tense, thin membrane, is capable of carrying out at the same moment of time the greatest variety of vibrations. For instance, while it is carrying out the vibration which answers to the deepest tone, it can make the smaller vibrations, and in the midst of one of these, yet other two of only half the size, etc., etc. Moreover, it can even carry out dissonant vibrations at the same moment of time. In all these synchronous vibrations the handle of the hammer takes part, and transfers them to the membrane of the fenestra ovalis, from which they are transmitted through the fluid of the labyrinth to the terminal branches of the acoustic nerve; the transverse vibration on the membrana tympani being probably changed into horizontal by the pendulum-like vibrations of the stirrup.

A few remarks may be permitted in regard to the relative dimensions of the individual parts of the auditory apparatus.

If the cavity of the tympanum, whose essential function is to afford the *membrana tympani* free motion, were smaller, then too much force would be absorbed

through the condensation of the air contained within it; if it were greater, then, as we have said before, a disturbing resonance would occur in the case of the high tones.

The wave length of B, in water, amounts to $\frac{1453}{3960}$ metres $= 367^{mm.}$ If we estimate the length of the distance from the membrane of the fenestra rotunda through the scala tympani, the scala vestibuli, the vestibule, and the longest semicircular canal at $63^{mm.}$, then it would amount to more than $\frac{1}{6}$ of the aforementioned wave-length. From this it can be seen that the passages of the labyrinth could not be much longer without disturbing the uniform motion of the particles of water.

If the ossicles were considerably larger, it would be more difficult for them to come to rest, or to be put in motion again, than seems best. Were the membrana tympani much greater, it would be too apt to tear, or too clumsy.

The proportions of the individual parts of the auditory apparatus are dependent on a constant factor, the outer atmospheric air; therefore their absolute dimensions cannot vary much.

It is for this reason, too, that in the most different varieties of mammifers, the formation of whose skulls often deviates so much from our own, the individual elements of the organ of hearing differ but slightly from those of man. For the same reason, also, these elements in the child are but little different from what they are in the adult.

Among the authors who have written on this subject, Chladni is the one to whose opinion our interpretation

of the final mechanical effect of the auditory apparatus comes nearest. He says (page 329 of his "Traité d'Acoustique"): "The vibrations which are communicated to the two fenestræ of the labyrinth affect the entire mass of water contained within it; for, as in general, every pressure exerted upon a fluid is extended to the entire mass in such a way that every molecule of it feels the same pressure. It can therefore be assumed that this pressure is exerted upon the entire nerve substance contained within the labyrinth; and it is not in harmony with nature to maintain that every tone affects only certain parts (of the nerve substance). These impressions upon the entire substance may, however, take place in an endless variety of ways; and if several tones are heard at the same time, all the vibrations necessary for this purpose will occur at the same time without interfering with one another, as it is the case with (molecular) motions in general. The labyrinth appears to be constructed in this complicated manner in order that all kinds of impressions may be produced with the greatest facility."

CORRECTION.—In my paper on binocular vision, in the first number of these Archives, there occurred to me a slip of the pen, which I beg leave to correct here. From the statement on page 188, line 14, etc., it would follow that the angle of wheel-rotation is o when the point of fixation lies in the median plane. This is incorrect (see my paper on the Horopter, in Graefe's Archives, XV., 1, pages 123 and 126). This angle, on the contrary, is o, as follows from the quoted formula of Listing, when the visual line of the eye is parallel with the median plane, or, in vertical position of the head, horizontal.

THE DIAGNOSIS OF INTRA-OCULAR SARCOMATA.

By Dr. OTTO BECKER,

Prof. of Ophthalmology in the University of Heidelberg.

(WITH CHROMO-LITHOGRAPHIC PLATES A AND B),

(Translated from the German by E. GRUENING, M.D., of New York, Assistant to the New York Ophthalmic and Aural Institute.)

At the meeting of the Ophthalmological Congress, in the year 1868, at Heidelberg, a discussion arose with reference to a paper on choroidal sarcomata, by Prof. Knapp, between the latter and Dr. Wecker, of Paris, whether the commencement of sarcoma is complicated with detachment of the retina, as Dr. Wecker asserts, or, whether tumors may remain in contact with the outer surface of the retina during a certain period of their development, which opinion Dr. Knapp seems to advocate. Von Graefe considered both—the presence of retinal detachments and their absence during the first stage—to have been proved by observation. According to his experience, however, detachment of the retina occurs in the majority of cases. He had but rarely had the opportunity of examining with the ophthalmoscope small choroidal sarcomata in the fundus of the eye, whilst it happened to him several

times in every year that a choroidal tumor escaped his notice under the disguise of a detachment of the retina, or that a suspicion of its existence was excited only by other reasons. He added, that the difference of location of the tumor with regard to the veins might possibly explain why, in some cases, serous effusion set in at an early period, whilst in other cases it was wanting.

Whilst in text-books of ophthalmology, as well as in illustrated works on ophthalmoscopy, detailed statements on the diagnosis of commencing choroidal tumors are missing, so that we must rely on the expositions of Von Graefe (Archiv für Oph., 1, 2, p. 233), Dr. Knapp endeavors in his book on Intra-Ocular Tumors, p. 249, etc., to treat more thoroughly of the diagnosis of choroidal sarcoma. In this treatise he traces the four stages which he ascribes to the sarcoma of the choroid. These stages are the following:—1. Development of the primary sarcomatous intumescence of the choroid without noticeable symptoms of irritation in the eyes. 2. Presence of inflammatory symptoms in the globe resembling glaucoma. 3. Extension of the pseudo-plasm to the surroundings of the eye-ball. 4. Generalization of it by way of metastases in other organs. Omitting both the latter stages, a separation of which may not always be possible, I only repeat what has been written on the diagnosis of such tumors in their second and first stages. I have already mentioned that the principal difficulty in the diagnosis of choroidal sarcoma lies in the detachment of the retina, which nearly always accompanies the tumor.

To Prof. Von Graefe is due the merit of having pointed out that behind retinal detachment, in all probability, a tumor is concealed whenever increase of intraocular pressure and ciliary neurosis supervene. (A. f. O., IV., 2, p. 211.)

We know at present that on the one hand tension may be exceptionally increased in simple detachment of the retina, whilst on the other hand it may every now and then be diminished even in sarcoma of the choroid. Dr. Knapp (l. c., p. 251) enters minutely into the details of the differential diagnosis of tumors, glaucoma, and other affections with which a limitation of the visual field is connected.

The differential diagnosis of the first stage of choroidal sarcoma, of which I intend at present to speak, has likewise been treated most thoroughly by Prof. Knapp, although it must be conceded that Von Graefe's remarks on the subject have not been surpassed. I therefore beg leave to republish his so-frequently quoted words, since they will constitute the starting-point of our considerations.

"As regards the first development of sarcoma of the choroid, I have gradually arrived at the conviction that the early appearance of serous inflammations of the retina forms the rule. Therefore, with the exception of tumors in the region of the ciliary body, it will hardly be possible, ophthalmoscopically, to diagnosticate the first commencement of a choroidal sarcoma; we will rather, in the beginning of the affection, have a simple detachment of the retina before us; may perhaps have some re-

mote suspicion from the absence of the causes usually producing the same (scleral staphyloma, affection of the vitreous, inflammatory processes, hemorrhagic extravasations, scleral cicatrices), but to diagnosticate with certainty in this stage can hardly be thought of."

Suspicious rigid lumps, occasionally pigmented, do not come into view until in the course of the development of the growth the retinal fluid becomes more and more dis placed, and the mass of the tumor again approaches the retina. The appearance of those lumps, in addition to floating portions of the retina, rouses the above-mentioned suspicion, the probability of which becomes heightened when, with the advancement of the tumor, the intraocular pressure progressively increases.

In this very exposition Von Graefe points out a difference, with regard to the accompanying detachment of the retina, between such tumors as take their origin from the ciliary region and such as spring from portions of the choroid lined with the retina. The former may, at a later period, give rise to a retinal detachment; still, this casualty does not happen so readily, on account of the pars ciliaris retinæ having a far more intimate connection with the uvea than the retina proper with the choroid. In the discussions of the Ophthalmological Congress of 1868, Von Graefe, however, conceded, as mentioned above, the possibility of the development of choroidal tumors without subsequent detachment of the retina.

The number of choroidal sarcomata in my pathological

collection amounts to sixteen, four of which confine themselves to the bulb of the eye, while three of them have altered the shape of the bulb without perforating the sclerotic, and the remaining nine have wrought intimate connections with the surrounding tissues. I had an opportunity of observing three of these tumors in their first stage (according to Knapp). In a living person I have never met with a choroidal sarcoma originating in the ciliary body. There are, however, three cases among those enumerated above, which, relative to the manner of their first appearance and total development, deserve, in my opinion, a special clinical consideration. I speak of sarcomata taking their starting-point exactly in the region of the macula lutea, where they can be observed and examined ophthalmoscopically in the first stage of their evolution. These tumors must needs be considered completely intraocular, since there is neither an impediment in motility nor a projection of the bulb discoverable.

1. The first case of this kind came under my observation in 1865. A short time after I had found the first intra-ocular cysticercus in Vienna, Dr. Tetzer consulted me with regard to one of his female patients, who, in the posterior pole of the eye, exhibited a retinal projection behind which a cysticercus was suspected. The woman was forty and odd years old, in good health, and in a state of vigor corresponding to her age. The transparent media of both eyes were clear. In the left eye I found in the region of the macula lutea a round white spot, of four times the size of the papilla, without well-marked edges, and traversed by dilated vessels. It projected to such a degree as to bring distinctly into view the summit of the prominence by means of a convex lens No. 10, the fundus being plainly discernible without cor-

rection by an emmetropic eye. The general aspect of the arrangement of the vessels bore a resemblance to the well-known retinal injection. It was striking that in a situation where by the aid of the ophthalmoscope generally no vessels can be perceived, a plainly developed vascular system had formed. At that time I examined the woman repeatedly in the course of several weeks. Not being able, however, to trace the outlines of a vesicle behind the retina, and there being neither phenomena of motion nor an increase in size perceptible, we dropped our supposition of cysticercus and suspended the diagnosis.

The visual disturbance of the patient consisted in a central defect of the field of vision, corresponding strictly to the projection perceived by the ophthalmoscope. Eccentric vision was nearly as good as in the healthy right eye.

Two years subsequently, Dr. Tetzer having died in the mean time, I assisted Prof. Arlt in the enucleation of an eye in a case of orbital tumor connected with the bulb. I was greatly surprised to recognize the patient as the identical lady whom I had previously examined. Dr. Tetzer being dead, it is impossible for me to communicate anything concerning the further development of this highly interesting ophthalmoscopic appearance, the patient, according to my knowledge, only having been under the observation of Prof. Arlt a short time prior to the operation. When I first met the patient again, immediately before the operation, I found a very considerable exophthalmus, the cornea intact and clear, the lens transparent, but the vitreous body so turbid that the fundus could not be perceived. Visual power was totally extinct.

We succeeded in removing the bulb, together with the neoplasm, without cutting into the latter. Fig. 1 is a 4-in. diagram of the horizontal section. It shows, first of all, that the optic nerve, cut more than half an inch behind the bulb, exhibited a completely healthy appearance in its larger posterior portion. Interrupting the description of the diagram, I may add that the patient, in spite

of the tumor having been successfully enucleated, and the optic nerve cut at a considerable distance from the bulb,

FIG. 1.

died a few months subsequent to the operation, without manifesting, if I remember well, a local recurrence of the affection. In the autopsy numerous melanotic sarcomata were found in nearly all the abdominal organs, but chiefly in the liver. The microscopical examination of the tumor revealed a sarcoma consisting of fusiform cells of extraordinay size. The shaded parts of the diagram were richly pigmented, while the light portions presented, in the fresh section, a pale-yellow appearance, and contained little or no pigment at all.

The appearance of the tumor in the interior of the eye is really striking. The vitreous body is intersected by membranes, which, viewed by the microscope, are found to consist of very fine ramified cells. The retina is everywhere in contact with the choroid, excepting in the regions of the optic nerve and macula lutea, where it is raised by a flat elevation. This prominence is occasioned by a

black pigmentary mass, which, as the diagram demonstrates, consists of two small, isolated lumps, breaks through the sclerotic in the region of the macula lutea, and passes posteriorly into the tumor situated on the outside of the optic nerve. It is obvious that the blindness depended upon the proliferation of the neoplasm into the optic papilla. The retinal projection observed two years prior to death was caused by a relatively small portion of the tumor rising internally beyond the normal level of the choroid. It is a very surprising fact, that a neoplasma having taken its origin in the interior of the eye, and perforated the sclerotic, should externally attain the size of a pigeon's egg, and internally grow but inconsiderably in the course of two years. With a great degree of probability we may assume that, at the first examination, there existed no growth on the outside of the globe. Estimating .the size of an intumescence which, two years ago, would have produced the then observed degree of retinal projection, we must concede that the tumor could hardly have been of much greater size than that of the dead eye under consideration.

2. Several weeks subsequently, a man, complaining of bad sight in his right eye, presented himself in the Clinic of Prof. Arlt. The eye exhibited the so-called glaucomatous condition, but with a central defect of the visual field and peripheral perception of light everywhere. It was impossible by an ophthalmoscopical examination to perceive the fundus of the eye clearly, on account of numerous opacities in the vitreous humor. We succeeded, however, in detecting a retinal prominence of moderate size, exactly in the region of the posterior pole. We

could discover no vessels, neither active nor passive motions; and since primary glaucoma could be excluded, we were led by the increased tension to infer, with some degree of probability, the presence of a tumor. Enucleation was proposed, but rejected by the patient.

FIG. 2.

On the 29th of September, 1868, I recognized in the clinic of Prof. Billroth, of Vienna, this very patient from whom an orbital tumor of the size of an apple had been removed. Fig. 2 represents a section of the tumor. The cornea is destroyed, and has given issue to the lens; the shape of the globe is pretty well preserved. In the region of the posterior pole we find a tumor, which has consumed the choroid, raised the retina, and perforated the sclerotic. The optic nerve is relatively well separated from the mass of the tumor, and contains but few sarcomatous elements in different spots. Externally the tumor had assumed extraordinary dimensions, occupying during life not only the whole of the orbital cavity, but also proliferating beyond it, and forcing the remains of the globe forward.

In this specimen we meet likewise with the very strik-

ing fact that a tumor, springing undoubtedly from the interior of the globe, exhibits there a relatively insignificant development, while, after breaking through the sclerotic, it attains externally very considerable dimensions. It also deserves special mention that, in this case as in the former, the neoplasma originated exactly behind the macula lutea.

The microscopical examination revealed a sarcoma consisting of small round cells. The case is the same reported by Billroth (Chirurgische Klinik, Wien, 1868, p. 35). There it is stated: "The tumor, situated between the bulb and the muscles, had enclosed the former completely, without having grown beyond it. Fig. 2 demonstrates that the last statement is not fully correct. The patient had a recurrence of the affection in the orbit on the 15th of May, 1869.

3. On the 21st of October, 1869, I was consulted by Sister Ph., of the convent at Niederbrunn, Alsace. She stated that she had lost central vision in her right eye several weeks ago. The dark spot had been small in the beginning, but it gradually extended in size, and vision is at present much deranged, even when both eyes are kept open. The examination revealed a complete state of health of the anterior structures of the eyes, and transparency of the optic media. In the region of the macula lutea I could perceive, ophthalmoscopically, a whitish prominence, of an oval shape in the transverse direction, and consisting of two protuberances of different size. The surface of the elevation presented a hazy appearance, the retinal vessels were dilated, and my attention was chiefly called to a wide vein which advanced to the centre of the macula lutea, and there became lost in the tissue. In this situation there are certainly no vessels visible in

normal eyes. The edges of the tumor were gradually sloping towards the level of the retina, and the retinal vessels were seen to wind their course up the tumor without any interruption whatever. No interval could be perceived between the tumor and the retina.

Examining the functions of the eye, I found, instead of direct vision, a completely well circumscribed defect of the visual field, while peripheral vision had remained unaltered.

I made the diagnosis of choroidal sarcoma at once, reserving, however, my statement till I would have perceived a distinct increase in size within a relatively short space of time. I determined upon an operation as soon as I had succeeded, by repeated examinations, to discover through the somewhat opaque retina, and in the mass of the tumor, numerous extraordinarily pale vessels, lying in close vicinity to each other. I considered these to be newly formed vessels, because I had not detected them previously, even by very careful inspection. My view was rather corroborated by the fact that the arrangement of these vessels neither corresponded to the conformation of the retinal nor of the choroidal vessels. Immediately after the enucleation I made an equatorial section of the bulb, and had the specimen drawn. (Fig. 3.) The section passed through the tumor, perceived ophthalmoscopically in the region of the macula lutea, and hit rather peripherally upon another small sarcomatous lump, to which the retina was also closely adherent.

In these three cases, in which I had an opportunity of examining choroidal sarcomata with the ophthalmoscope,

in the incipient stage of their development, the tumors had already grown to such an extent as to injure sight

FIG. 3.

considerably, and yet no trace of retinal detachment existed; on the contrary, both specular examination and the anatomical specimen demonstrated the immediate contact of the retina with the tumor.

I am obliged to state, that the eyes were examined ophthalmoscopically during a relatively short period of time in the evolution of the growth. With regard to the first two cases I must concede that, concerning the point in question, I have to rely upon my memory, not having taken notes at the time of observation. One would also be of opinion that my attention had not been called to this very subject at that time, on account of the controversy not having been raised yet. As regards the last case, however, I maintain the indisputable fact, that the specular examination admitted of no other inference but that the retina was as inti-

mately connected with the tumor as with the choroid laterally.

While ophthalmoscopical examinations did not prove sufficient to settle the point in question in all three cases, the anatomical investigation was more conclusive. In the first and third specimens, the retina lies in immediate contact with the choroidal sarcoma, although the third case represents a recent tumor, and the first a growth of several years' standing.

I admit, of course, that these cases differ from the ordinary form of sarcoma. A choroidal sarcoma existing any length of time and advancing toward the vitreous body assumes rapidly, if not from the very beginning, a more or less globular shape; but the tumors under consideration project but inconsiderably, and do not rise steeply: they are flattened, and overlap the choroid to a less degree. The physical conditions hence favor a more permanent contact of the retina with its substratum. These tumors differ, furthermore, from ordinary sarcomata in the fact of their being situated in the posterior pole of the eye.

Von Graefe admits that sarcomata springing from the ciliary body form an exception with regard to their relation to the retina. This circumstance depends upon the more intimate regional connection of the retina with its substratum. An analogous condition exists in the region of the macula lutea. It is well known that choroidal veins are but exceptionally given off from that part of the eye, and this very circumstance might add to explain why

sarcomata, forming in that region, remain, during the period of their growth, constantly in contact with the retina without giving rise to its premature detachment.

But even choroidal sarcomata not springing from either of the mentioned regions may, in some rare cases, exhibit, during the whole time of their development, either a very small quantity of fluid or none whatever between the tumor and the retina. In these cases the diagnosis of choroidal sarcoma can be made even solely from the shape of the retina, which has become forced into the vitreous body. I shall endeavor to substantiate this assertion by several cases that came under my observation.

4. In June, 1866, Th. B——, who three years previously had been operated on for cataract with a very good result, by Prof. Arlt, and since then had been able to pursue with the operated eye the calling of a country-town teacher, presented himself at the clinic, complaining of a diminution in sight of recent date. Examining the patient, we found good central vision, while the lower and inner part of the visual field presented a very considerable defect. Corresponding to this limitation of the field of vision, the ophthalmoscope revealed, in an upper and outer situation, an almost globular mass covered by the retina, and projecting into the pupillary space. The retina did not exhibit the ordinary blue color usually found in cases of excessive detachment; neither characteristic folds nor oscillations upon moving the eye could be detected. The vessels were neither of brown nor black, but of normal color. None but retinal vessels were to be discovered. Inspecting the surroundings of the tumor, we saw the fundus of the eye clearly and distinctly, the vitreous body being completely transparent. The papilla was readily brought into sight, and it was found that, at a short distance from it, the retina was slightly detached toward the tumor.

Bringing into focus the vessels situated at a short distance behind

the lens and upon the surface of the tumor, one could everywhere pursue their course back to the edge of the convex mass, and convince one's self of the posterior direction which they took. Examining alternately the direct and the inverted images, and combining the latter method with the manipulation of producing prismatic displacements by means of lateral movements of a convex lens, one was almost forced to the conclusion that posteriorly the tumor diminished in circumference, thus constituting a pedunculated growth. As mentioned above, no pouch of detached retina could be detected anywhere, and we even argued that the retina was posteriorly more or less firmly adherent to the peduncle of the tumor. A simple serous detachment of the retina can never assume this form, and I am therefore of opinion *that the diagnosis of choroidal sarcoma can be founded upon the existence of a tumor of that shape.*

We resorted to a probatory retinal puncture through the vitreous body. The tumor bled freely, but did not collapse. The patient, not consenting to have the eye enucleated, left the clinic. Three months subsequently he returned, with his eye in a glaucomatous condition. An iridectomy was performed, but failed to relieve the pain. When we finally enucleated the eye, the tumor had already broken through into the orbit. Three months subsequent to the operation the affection recurred, compelling us to remove completely the contents of the orbit. Though this was readily done without leaving behind parts of the tumor, the patient was not benefited by it, but died of apoplexy the next day. The microscopical examination revealed a choroid sarcoma consisting of large cells, and containing but a trifling quantity of pigment.

5. I met with a very similar case in the person of the steward, C. F——, of Leesdorf, near Baden. The ophthalmoscopic appearance was so analogous to that of the preceding case that a description would merely constitute a repetition, and I shall simply mention that, in this case, I was able to perceive through the retina several branches of a vascular system situated upon a posterior plane, and showing an unusual arrangement. The diagnosis could be readily based upon this very sign. It was rather striking that two years subsequent to the first examination

the eye was found free from pain and increased tension. I am unable to give a further account of the history of this case, as I lost sight of the man in consequence of my departure from Vienna.

In the following case my observations were more complete.

6. L. R——, clerk, æt. 28, enjoyed good health up to March, 1867. At that time he noticed that his sight became impaired without an assignable cause; he was, however, free from pain. At the end of March he consulted a renowned ophthalmologist of Vienna, who instilled atropine, and, after examination, proposed to puncture the detached retina; the patient did not consent to have it done, but called on me. On examination I found the very details of both the preceding cases. The patient read Jäger No. 4 at five to seven inches; acuteness of vision being $\frac{20}{30}$. The state of refraction was emmetropic, and the left eye completely healthy. I admitted the patient for observation to the ophthalmic clinic, where he remained three weeks. The diagram of Plate A was executed immediately after his admission, and gives a far better idea of the then observed ophthalmoscopical appearance than a detailed description. A pedunculated globular mass, situated closely behind the lens, and covered by the retina, projected from outwards so far toward the visual axis of the eye that the region of the macula lutea could just be examined. Nothing abnormal was found in the papilla and its vicinity. On the surface of the tumor the large retinal vessels were distinctly perceptible, several of them with extravasation spots along their walls. Looking at the centre of the tumor, it appeared of a whitish, pale-red color, while its extreme limits presented a blue color. Employing the mirror in different foci, I came to the conclusion that another circular outline could be discerned on a somewhat posterior plane behind the detached retina. The retina, hence, was separated from the tumor beneath by a thin layer of fluid. Plate B shows this condition very distinctly. It was sketched four weeks subsequently, the tumor in the mean while having undergone considerable changes.

In this case I first employed a method of examination not yet mentioned in text-books of ophthalmoscopy. By that method the highest possible magnifying power of the ophthalmoscope is obtained. In high degrees of hyperopia, the size of the image bears a direct ratio to the power of the retrospecular lens employed. The nearer, in a given case, the observed eye is approached, the stronger the convex glass ought to be. If the latter be adjusted behind the mirror, this instrument must be held at a distance of at least two inches from the eye. An additional approximation can only be attained by holding the convex glass between the mirror and the eye. Thus it becomes possible to employ the lens at a distance of a few lines from the anterior principal point of the eye. The increase in size attained is the greater the more the correcting glass approaches the eye, the power of the employed convex lens increasing in the same ratio.

By this method I succeeded in perceiving in and behind the retina alterations which whould have escaped my attention. The hemorrhagic spots of the retina were gradually absorbed, but behind them several red bands with well marked outlines, and characterized by their anastomoses as vessels, became visible. The latter are represented on Plate B, behind the narrow filiform retinal vessels, as considerably wide anastomosing bands, of a uniformly red color. In their course they neither exhibit a resemblance to retinal nor choroidal vessels, and are therefore to be considered as newly formed, and belonging to the neoplasm.

The diagnosis was thus settled, and there existed no doubt as to the course to be pursued. The patient refused to have enucleation performed at once, and was therefore discharged from the clinic, and advised to return as soon as the eye became painful. On the first of December, 1867, the patient submitted to the operation after having suffered from pain for eight days. The eye had passed into the so-called glaucomatous stage. The neoplasm, examined microscopically, was found to be a choroidal sarcoma.

A few weeks ago I wrote to the patient, and he informed me that at the present time, winter 1869–'70, two years after the operation, he enjoyed good health, the affection not having recurred.

7. As a curious fact I will mention, that the very day I have been writing this paper, February 25th, 1870, I was consulted by a farmer, aged 58, of the neighboring village of Pl., whose right eye presented the very same aspect described in the three preceding cases. A globular mass, covered by the retina, projected into the pupillary space of the right eye. Employing the mode of examination mentioned above, a neck-like constriction could likewise be demonstrated posteriorly. A convex lens, brought as near to the eye as possible, did not only render visible the capillaries of the retina, but also behind the latter, and on a posterior plane, the newly formed vessels of the tumor. The extreme sharp edge appeared of a somewhat bluish color, which admitted of the inference that a very thin layer of serous fluid was situated between the retina and the tumor. This diagnosis admits of no doubt, the very vessels of the tumor being perceptible. But even if no vessels could be seen, I would not have hesitated to diagnosticate a choroidal tumor from the peculiar shape.

Basing upon my own observations communicated in

this paper, and upon the remarks of other observers, I consider myself entitled to assert, that it depends upon the situation of a choroidal sarcoma whether it can be distinguished with certainty, and at an early period, from a detachment of the retina.

I. It has been asserted by Knapp (l. c.), and conceded by Von Graefe, that a sarcoma, taking its origin from the ciliary body, can remain in contact with the retina during the whole period of development and still be diagnosticated; since the occurrence of retinal detachment cannot take place in this situation, in consequence of the intimate connection existing between the pars ciliaris retinæ and the corpus ciliare. In a special case Knapp had an opportunity of demonstrating the existence of a choroidal tumor by the fact that the latter, in its growth, tore the iris from its ciliary attachment.

II. Choroidal sarcomata originating (as cases 1, 2, 3) in the region of the macula lutea, seem from the very beginning to have but little disposition to proliferate in the interior of the eye, but are prone to develop posteriorly in the orbit. Both of those cases, at least, which I had an opportunity of observing during a certain period of time, remained stationary in the interior of the eye, at a relatively inconsiderable phase of their development. As minutely stated above, it probably depends upon anatomical conditions, that in this situation the retina never becomes detached from the tumor by a serous effusion. *And thus it seems to be proved that choroidal sarcomata really do exist during a cer-*

tain length of time without the supervention of retinal detachment.

III. In the aspect of choroidal sarcomata of a more advanced stage a marked difference presents itself, depending upon the upper, lower, or lateral intra-ocular origin of the tumor. It cannot be denied that in these cases the retina has nearly always been found somewhat detached from the growing tumor by a serous effusion. But the cases which I reported have not been observed in the first stage of their development, and we will but rarely have an opportunity of examining such cases, since choroidal sarcomata of small size, and developing peripherally, produce no functional disturbance, and can only be detected by chance. If a tumor of this description be located in the lower half of the globe the serous effusion will spread on all sides, while the retina remains in contact with the summit of the tumor. The whole will therefore present the aspect of a more or less projecting retinal detachment with a broad base. Should the case finally become accessible to observation, on account of functional disturbances, it will depend upon accompanying phenomena, as turbidity of the vitreous humor, etc., etc., whether the small point of adhesion between the retina and the tumor is detected, and vessels are perceived. Without seeing the latter it would be impossible, in the first stage of development, to distinguish between a detachment of the retina and a tumor. A sarcoma developing from the upper wall of the globe will likewise only by accident come under observation in

the first stage of its development. The tumor will also, in this region, occasion a serous effusion, but the gravitating fluid will collect around the tumor in a different manner. The retina, forced by the neoplasm in a direction from above downwards against the vitreous humor, forms a vertically suspended pouch. It is easily understood that in this situation of the tumor, the base of the latter shows either a very inconsiderable retinal detachment or none at all, while serous fluid, collecting in a retinal pouch, surrounds the body proper of the neoplasm and reproduces the particular shape of the tumor. In accordance with this observation, such choroidal tumors as originate exactly from the centre of the upper wall show no trace of retinal detachment at the base, while in a lateral situation the retina never fails to become somewhat detached.

It depends upon the quantity of fluid found between the tumor and the detached retina whether the former can or cannot be perceived through the retina. If the former be the case, the diagnosis becomes indisputably settled. Should neither vessels nor another outline be discernible behind the detached retina, the shape of the latter, reproducing the outlines of the tumor, will indicate the presence of choroidal sarcoma.

It furthermore deserves special consideration that upon the surface of choroidal sarcomata which, in the course of their growth, advance their summits near to the visual axis, a development of vessels can be observed. In case 6 I had an opportunity of pursuing from day to

day, and occasionally from hour to hour, the gradual presentation of a widely reticulated vascular network belonging to the choroidal sarcoma. According to Von Graefe's statement, mentioned above, this phenomenon could be explained by the reapplication of the retina in the course of the further development of the sarcoma and the absorption of the effused fluid. My observation in case 6 tends to maintain that vessels situated on the surface of the tumor develop with particular energy only at that period. Cases 5 and 6 demonstrate that in this phase of development the tumor occasionally exhibits a temporary cessation of growth, during which period we might imagine its inner organization, upon which the formation of superficial vessels depends, becomes more complete.

In case 6 I observed that in the beginning the vessels were wide and faintly limited, analogous to embryonic vessels, but subsequently became metamorphosed into a regular vascular network with well-defined outlines. It even seemed that, in one place, well-defined vessels had gradually been forming in a red spot, bearing the appearance of extravasated blood. The close approximation of the intumescence to the posterior nodal point of the dioptric system, affording great accuracy of examination, should have rendered it possible to observe that the distance between the retina and the surface of the tumor decreased at the rate of the progressive absorption of the fluid effusion. But such changes I did not recognize.

A PRELIMINARY NOTICE ON THE ANATOMY AND PHYSIOLOGY OF THE EUSTACHIAN TUBE.

By PROF. MOOS.

Translated by Albert H. Buck, M.D.

An article published by Prof. Rüdinger in the April number of the Monatschrift für Ohrenheilkunde, 1869, compels me, against my original intention, to make the following brief communication.

The investigations which I commenced a year ago in the institute of Prof. Julius Arnold, and have carried on ever since, led me to the belief that the Eustachian tube is closed beyond the ostium pharyngeum. In those cases where the peculiar shape of the cartilage requires it (in man, in cows, and in oxen), the closure is effected by a peculiar cone-like intumescence of the mucous membrane. In others, the thickness of the mucous membrane alone suffices to effect a closure. This cone-like intumescence in the ox and cow, which hitherto has escaped the notice of the authors who have studied this subject, gains a new physiological interest from the fact that in the calf it is entirely wanting. The above results

were obtained on Eustachian tubes of men and animals, prepared according to different methods.

In order to preclude future discussions as to whether my investigations were independent of the published statements of others, I must say here that the preparations demonstrating these points were shown last autumn to Prof. Julius Arnold, to Prof. Simon, and to Dr. F. A. Pagenstecher, in the Heidelberg Pathological Institute. In November, 1868, I communicated to Prof. Helmholtz these same results relative to the closure of the Eustachian tube when in a state of rest, and mentioned especially the cone-like intumescence. Already in August, 1868, I sent preparations illustrating this point to Dr. Politzer, in Vienna, and wrote to him my belief that the Eustachian tube in a state of rest is closed. On the 26th of March, 1869, moreover, during my stay in Munich, I discussed this very topic with Prof. Rüdinger (who, until quite recently, as is well known, held the opposite opinion), and expressed to him my belief that the Eustachian tube is closed in a state of rest, and that in man the closure is effected by a cone-like intumescence of the mucous membrane.

HEIDELBERG, May 29, 1869.

NOTE 1.—The above preliminary notice appeared in the first number of the German edition of these Archives, in July, 1869, when the print of the English edition was already completed.

NOTE 2.—In the note at the end of the article (Vol. i., No. 1, p. 9, of these Archives) entitled, "Entoptic Phenomena Connected with the Circulation of the Blood," for Strabismus *Externus*, read Strabismus *Internus*.

H. KNAPP.

EXPLANATION OF PLATES.

PLATE I.—*Vertical section through the Stirrup.*

THE base of the Stirrup (C) lies between the lower (A) and upper (B) borders of the fenestra ovalis. *a* corresponds to the side turned toward the tympanum, *b* to that facing the vestibule. The lower end, *c*, is somewhat more flattened than the upper, *d*. On its inner or vestibular side the base of the Stirrup is cartilaginous, whilst toward the tympanum it consists almost entirely of bone. The margin of the fenestra ovalis is also cartilaginous. A band, *e*, of connective tissue, rich in nuclei, stretches from the border of the base of the Stirrup to the opposite margin of the fenestra ovalis. On the vestibular side the base of the Stirrup is covered by a fibrous membrane, *f*, or periosteum. Toward the tympanum it is covered by a similar membrane, which, in the drawing, is only visible at *g* near the margin. 25 diameters.

PLATE II.—*Horizontal section through the Stirrup.*

(Only the ends of the base C are given in the drawing.) Toward the cavity of the tympanum *a'* the base of the Stirrup consists almost entirely of bone; toward the vestibule *b'* there is a peripheral zone of cartilage. The anterior end A is rounded, whilst the posterior B is flattened; both are cartilaginous at the periphery. Toward the cavity of the tympanum, as well as toward that of the vestibule, the base C is covered by a fibrous membrane. *d* represents the tense band of connective tissue which stretches from the margin of the fenestra to the opposite border of the base of the Stirrup. 25 diameters.

The colored plates A and B represent the ophthalmoscopic appearances of a case of *Choroidal Sarcoma*, a detailed description of which is to be found on pages 710 and 711 of this volume.

INDEX.

Tab. B.

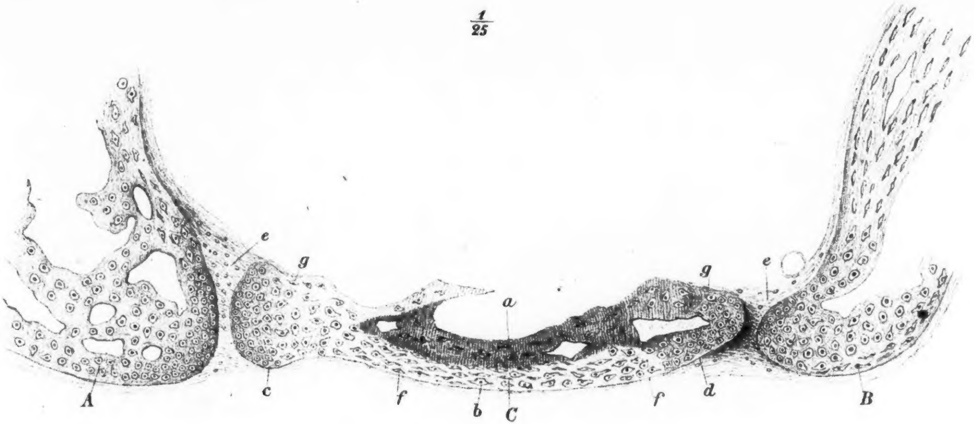
Sarcoma chorioideae II.

Dr. C. Heitzmann ad nat. del.

Carlsruhe. _ Chr. Fr. Müller'sche Lith. Anstalt

Tab. I.

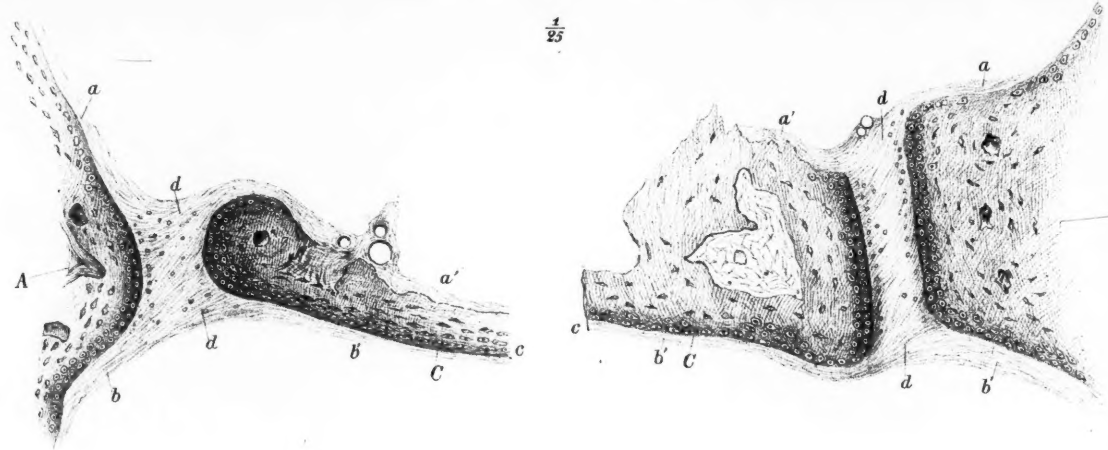
$\frac{1}{25}$



F. Veith ad. nat. del.

Carlsruhe... Chr. Fr. Müller'sche Lith. Anstalt

Tab. II.



F. Verth ad nat. del.

Carlsruhe. Chr. Fr. Müller'sche Lith. Anstalt.

Knapp & Moos Archiv, I 2.